Review on Nanomaterials Properties Produced by Laser Technique

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Abstract. The optical properties such as scattering and absorption as well as the morphological properties such as shape and size for the nanomaterials produced by laser were studied in details by different researchers. They used different laser techniques to produce nanoparticles such as Pulsed Laser Deposition (PLD), Pulse Laser Ablation (PLA), and Pulsed Laser Ablation in Liquid (PLAL). These laser techniques were used to prepare different nanomaterials such as gold, silver, cadmium, zinc sulfide, titanium, and zinc oxide nanoparticles. The optical and morphological properties were studied using different testing techniques such as X-ray Diffraction (XRD) patterns, Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), Fourier Transform Infra-Red (FTIR), and Scanning Electron Microscopy – Energy Diffraction X-ray (SEM-EDX).

Keywords. Nanomaterials, Optical properties, Morphological properties, Laser techniques

1. Introduction
Nanomaterials are cornerstones of nano science and nanotechnology. Nanostructure science and technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few years as shown in figure (1)[1]. Nanoparticles NPs and nanostructure materials NSMs can also be classified as natural or synthetic, based on their origin [2]. Nanomaterials can be normally occurring or physically, mechanically, or naturally composed with different structures, Figure 2 [3]. It has the potential to revolutionize the ways in which materials and products are created and the range and nature of functionalities that can be accessed. It already has a significant commercial absorbance, which will assuredly increase in the future [4]. Nanomaterials have a minuscule size which has in any event $1D \leq 100$ nm. The application of nanomaterials can be nanoscale in 1D for example films covers, 2D such as strands or filaments, or 3D such as particles as shown in figure 3[5]. Nanomaterials had applications in the field of nanotechnology and show diverse physical-substance qualities from typical synthetics (i.e., silver nano, carbon nanotube, fullerene, photocatalyst, carbon nano, silica). These particles can be used in numerous applications, for instance electrochemistry,
photochemistry, biomedicine, etc. [6-11]. Nanomaterials (gold, carbon, metals, metal oxides, and alloys) with a variety of morphologies (shapes) are shown in figure 4.

**Figure 1.** Evolution of science and technology [1].

**Figure 2.** Variance process for the preparing of nanoparticles [3].

**Figure 3.** Classification of Nanomaterials (a) 0D, (b) 1D, (c) 2D, (d) 3D [5].

**Figure 4.** Nanomaterials with a variety of morphologies [1]

### 2. Characterization of nanoparticles

Two of the fundamental factors studied in the properties of nanoparticles can be described by size and shape [12-14]. Also size circulation, degree of aggregation, charging surface, and area of surface were found, and the surface chemical properties and effect of the nanomaterial properties were fairly surveyed. Size including, size dissemination, and characteristic ligands presence outwardly of the particles may impact various characterizations in addition to some applications of the NPs. Furthermore, the structure of the nanoparticles and their concoction synthesis are completely examined as the first stage below nanoparticle synthesis. Recently, there are unnormalized indications for this point. Reasonable and strong evaluation techniques for nanoparticles will altogether vary the lift-up of these materials in working applications and grant the works to follow the rule. Regardless, there are huge challenges in the
investigation of nanomaterials because of the interdisciplinary thought of the field, such as nonappearance of sensible reference materials for the change of symptomatic gadgets, the difficulties associated with the model foundation for assessment and the comprehension of the data. Moreover, there are dismissed troubles in the depiction of nanoparticles, for instance, the assessment of their spotlight in situ and on-line, especially in a scaled-up creation, similarly as their assessment in complex systems [15]. With the increase of NPs, more reliable assessment strategies will be needed. Subsequently, it is critical to portray the nanomaterials masterminded in a couple of various approaches as far as possible. We don't only focus on the depiction of the nanoparticle focus, rather on a superficial level ligand that impact the physical properties as well. Furthermore, some methods are utilized to screen the energy of nanoparticle arrangement and study through some ongoing advances the point in the controlled deformities that urgently influence nanoparticle properties [16-18].

2.1. *Optical Properties*

The optical reaction of materials carries on straightly with the plentifulness of the electric field of light when electric field is related by low radiation [19-21]. The non-straight optics is treated with the "intensity of light", upon connection with material, varying its optical characteristics [22-25]. The non-straight characteristics of materials are pattern to variance at bigger energy containing nonlinear impacts, for example, self-centering scattering, and refraction. One of the most wonderful and valuable fields of nanomaterials is their optical properties [26-30]. Semiconductor and metallic nanomaterials have fascinating linear absorption, photoluminescence emission, and nonlinear optical properties. Nanomaterials hosting little molecule sizes show improved optical emission and nonlinear optical properties because of the quantum restriction effect. Synthesis, characterization, and estimation of optical properties of nanomaterials with separate anisotropic shapes draw significant consideration. Recently, many papers concentrate on the preparation of polymer semiconductor and other nano materials hosting a lot of applications in different optoelectronics and photonics instruments [31].

Optic characteristic represents a main phenomenon containing photocatalytic application of nanoparticles, during which photo chemists should consider the processes used for optical portrayal giving the root for the basic of lager lambert and the significance of light to uncover the instrument underneath photochemical procedures [32-34]. Optical portrayal processes were employed to accumulate data for nanoparticles absorption, reflectivity, phosphorescence and luminescence. Nanoparticles of different colors, especially, metallic and semiconductor NPs are significantly clear and are suitable for employment in applications of photographic. Information of the absorption and reflection data of these values are obtained from knowledge on all basic system applications. The knowledge of optical devices contain the UV, photoluminescence and none ellipsometers and are important for the fundamentals of optical characteristics of nanoparticles. The optical devices are additionally defined as UV-visible [35]. The UV/Diffuse Reflectance Spectrometer (DRS) is manly grouped constriction probability of estimating optical submission, admission and reflection. The aforementioned two are helpful to one another, while the last alluded (DRS) is an outstanding utilization of procedure for points of reference. The strategy for approving np bandgaps and unmistakable NMs is especially excellent. The photoactivity and conductance of the materials are fundamental for bundling the bandgap [34].

2.2. *Morphological properties*

Nanoparticles have an assortment of shapes and their names are portrayed by their various shapes. For instance, some nanospheres are round, nano reefs, nano boxes, nanoclusters, nanotubes, and so on. These shapes or morphologies now and then emerge unexpectedly as an effect of a templating or coordinating operator during combination for instance during micellar emulsions or anodized alumina pores, or from the inborn crystallographic development examples of the materials themselves [36]. Nanoparticles and nanostructured materials can be classified according to their base to carbon, inorganic, organic, and
composite nanomaterials [2]. NPs and NSMs can be synthesized by different morphologies such as those showed in Figure 5 based on the needed characteristics for the desired application [37-42].

The morphologies of nanoparticles help fill their different needs, for example, long carbon nanotubes being utilized to connect an electrical intersection. Formless particles normally receive a circular shape or nanospheres and anisotropic microcrystalline hairs compared to their specific precious stone shape. Little nanoparticles normally structure groups. These might be of different shapes like poles, strands, cups, etc. [2]. The morphological properties of NPs mainly gain prodigious attention due to the effective morphology which has great percentage of the nanoparticles characteristics. Many techniques are used to recognize nanoparticles to analyze their morphologic al properties, and the methods that are suitable for microscopy are Scanning Electron Microscope, Atomic Force Microscope and Polarized Optical Microscopy represent the famous techniques. The SEM technique is based on the low electron testing, and it introduces nanosized value for all capable information around the nanoparticles. reporting is greatly capable, during which individuals used these techniques to find the properties of their nanomaterials, as long as the scattering of nanoparticles in the mass or lattice [43]. The size of NPs can be measured using different tests for example SEM, AFM TEM, XRD, and (DLS). DLS may demonstrate inability to true estimating through the Differential Centrifugal Sedimentation (DCS) high-accuracy method is represented [44]. nanoparticles in fluid materials are studied and imagined in NTA method by examination the mean of Brownian movind to the size of the NP consequently permitting the size arrangements model of the NP to be placed in a liquid media with radius values from 5 to 500 nm [45]. (Unclear)

Figure 5. NMs according to variance morphologies: (A) 0D Pd NPs [36,37], (B) 2D Graphene [38], (C) 1D Ag [39], (D) 1D polyethylene oxide [40], (E)3D urchin-like ZnO nanowires [41], (F) 3D WO3 nanowire network [42].
3. Testing instruments

Different devices can be used to find the optical and morphological properties. These instruments can be listed as:

3.1. X-ray Diffraction

The XRD analysis is utilized to find the phase distribution and crystallinity for the synthesized nanoparticles. Figure (6) shows the X-ray Diffraction device [46]. X-ray diffractometers mainly contain three elements: An X-ray tube, a specimen holder, and an X-ray detector [47,48].

3.2. UV-VISIBLE analysis

The UV-Visible spectrum of nanomaterials solution synthesized at different laser techniques in the presence and absence of the magnetic field is shown in Figure- 7[48]. The UV-Visible spectrum gives a curve containing an SPR peak for the nanoparticles at different wavelengths $\lambda$ (nm) with respect to different pulse laser energies. The appearance of this SPR peak in this range is due to Mie scattering. The UV-Visible spectrometer is the suitable technique to calculate the size and shape of nanoparticles [49-51].

3.3. AFM analysis

The morphology of the prepared nanomaterials can be analyzed by atomic force microscope (AFM) with different laser energies in the presence and absence of magnetic field. This technique can give a visualization of individual particles and groups of particles in three dimensions, unlike other microscopy techniques. A few models of AFMs containing optical and electron microscopy systems are shown in figure 8 AFM [52,53].

3.4. Fourier transform infrared spectroscopy (FTIR)

Size distribution and characterization of the nanoparticle prepared by any laser techniques were founded further by FTIR. Figure 9 shows the FTIR spectrum instrument [48,54]

3.5. Scanning electron microscopy (SEM)

SEM is an instrument at which invisible objects or particles of microspace and nanospace will be observed with all details [55,56]. Three types of SEM can be recognized; conventional SEM (CSEM), environmental SEM (ESEM) and low vacuum SEM (LVSEM) [57]. Figure 10 shows all components of SEM [58], while Figure 11 shows different types of SEM [59,60], Figure 12.

![Figure 6. a) Schematic diagram of a XRD system[46] b) A Modern Automated X-RD Diffractometer[46]](image)
Figure 7. Schematic represent the mechanism of UV-vis spectra apparatus b) collecting of UV-vis spectra apparatus [49,50]

Figure 8. a) Schematic of Atomic Force Microscopy (AFM) b) Some atomic Force Microscope apparatus [52,53]
Figure 9. a) Schematic diagram of FTIR, b) FTIR apparatus [54].

Figure 10. Scanning Electron Microscopy (SEM) components [58]

Figure 11. A high SEM performance instrument [59].

Figure 12. Q250 analytical SEM for materials science [60].
4. Laser ablation
Laser ablation or photoablation is the techniques used for offsetting substance on the basis of a stiff (or sometimes fluid) face by projecting it by a laser light as shown in figure 13 [61-63], while figure 14 shows the component of laser ablation technique [64]. In little laser flow, the substance is heated up with the soaked-up laser power and vaporizes or distills. At bigger laser flow, the substance mainly turns up to a plasma [65]. Normally, laser ablation indicates offsetting substance on the basis of a beat laser, which is only capable of ablating substance by a continues signal laser light if the laser intenseness is suitably big. Nd:YAG clipper lasers of profound bright light are fundamentally utilized in photoablation; the frequency (wavelength) of laser utilized in photoablation is roughly 200 nm. The mechanism of laser ablation depends on physical properties of metals and environment medium. Therefore, the ablation of metals is an intricate subject [66–68].

![Figure 13](image13.png)

Figure 13. (a) Arrangement of NPS by laser in fluid [62] (b) Stages for particle generation by Laser ablation [67]

5. Nanomaterials synthesis by pulsed laser
Anatoly Tverjanovich, et.al, 2010 [69] created a polycrystalline bulk CuIn3Se5 tests for pulse laser deposition (PLD) focusing on using vacancy softening of 99.999% unadulterated components. All the (PNC) polynanocrystalline CuIn3Se5 slim movies are stored at the glass and glass/ITO substratum trough utilizing the PLD procedures. The time-temperature system of the PLD cycle was created for the readiness of (PNCs) CuIn3Se5 slim movies with a similar composition as the source target. Ampoules were embedded in a line heater, warmed more to 1100°C, maintained at this degree for 5 hours, then afterward

![Figure 14](image14.png)

Figure 14. The laser ablation technique components [68].
gradually cooled off. For the XRD estimation, the CuIn3Se5 filmstrips are kept onto glass backups; for examination of PV characteristics, the CuIn3Se5 films are distilled on the glass/ITO backups. The layers depth on glass/ITO wafers were found by utilizing optical measurement and microscopy observations. The mean depth of the distilled CuIn3Se5 filmstrips is about 300nm. The area and face morphology of the CuIn3Se5 layers are studied by scanning electron microscopy, utilizing a marketable high accuracy LEO SUPRA 35 microscopes fitted out by energy dispersive spectroscopy (EDS) analyzer. The authors concluded that the technique of pulsed laser deposition of CuIn3Se5 films was developed following thermal treatment allowed preparing the great photosensitive (PNC) dainty filmstrips of n-type conductivity. It was discovered that extra softening in a vacuum (after the PLD process, without opening the vacuum chamber) leads to increasing in the photosensitivity and improving (PNCs) structure of prepared CuIn3Se5 films. The best crystallinity of the CuIn3Se5 layers is attained at substrate temperatures ranging between 320°C and 400°C.

Yaha (2012) [70] produced (NC) nanocrystallites of cadmium oxide (CdO) skinny sheets by beat laser deposition method on glass backups utilizing Nd: YAG laser at λ (532nm). (XRD) designs affirmed the (NC) cube shaped CdO phase formation. The density of XRD tops rises with the rise in substrate temperature and good crystallinity occurs at a maximum temperature. The morphology of distilled filmstrips was recognized using (SEM) and (AFM); by rising backup temperature, the grain size and face asperity rise. The grain size value (12,18,47 nm) and RMS asperity numbers are 63.3, 98.8, and 138.4 nm for slim filmstrips deposited at 100, 200, and 300°C severally. UV–Vis spectrophotometric measurement showed max transparency (with 88 % at λ scope 500–900 nm) of the CdO thin film by a continuous omitted band hole esteem lengthened in the scope 2.81–3.7eV. The studied films were prepared from pure CdO targets and grown by pulsed laser deposition on an optically flat glass substrate kept in an axis distance of 4 cm from the CdO target. The CdO disc was ablated from 10-100 pulses (10- 20 min) to get single-layered thin films.

Hamed (2013) [71] produced a Zinc sulfide (ZnS) thin films utilizing beat laser destitution method. The laser utilized is the Q-exchanged Nd: YAG laser λ of 1064nm and 1Hz beat redundancy rate and differing laser power (700mJ-1000mJ) with 25 beats. The backup temperature was stored and fixed at 100°C. The auxiliary, morphological, and optical characteristics of ZnS slim films are described with (XRD), (SEM), (AFM), and UV-VIS spectrophotometer. ZnS slight films are distilled by utilizing the beat laser distillation procedure. The chamber is evacuate d to a normal pressure of (10−3 mbar) at a backup temperature of 100oC. Q-exchanged Nd: YAG laser with a λ of 1064 nm with various laser energies (700mJ-1000mJ) and a constant number of beats (25 beats) is utilized; the central length for the focal lens is about 13cm with a redundancy level of 1 Hz. The separation between the objective and the substrate was saved at 2.5 cm. Figure 15 shows the arrangement of PLD. After testimony, the auxiliary, morphological, and optical characteristics of ZnS flimsy films are portrayed by XRD), (AFM), and UV-VIS spectrophotometer.

Figure 15. A-schematic diagram of the PLD system[71]
Salminen (2013) [61] investigated pulses laser in the production of nanomaterials. This work was at first propelled by an enthusiasm to test late growth of high reiteration rate fiber lasers in (PLD) and (PLAL). PLD was utilized to store dainty films, NPs, and great face area facilities. The great replication level was seen to have significant ramifications for the nature of the kept filmstrips and the faces of the vaporized objectives. NPs delivered by regular chemical synthesis procedures frequently incorporate undesirable buildups from the reactants. These buildups can be harmful and negatively affect various applications. Nanoparticle creation by PLAL is a strategy equipped for delivering unadulterated NPs legitimately from a wide assortment of bulk materials and mixes.

Dorranian et al. (2013) [72] prepared a 6 - 12 nm silver NPs by the beat laser ablation of a high purity silver bulk in distilled water using the fundamental of Nd: YAG laser operating at 1064 nm with a pulse width of 7 ns and 10 Hz repetition rate. The effect of laser flowability on the size, morphology, and facilities of delivered NPs has been concentrated empirically on silver mass which was set at the lower part of water content with its surface at the point of convergence of a 80 mm curved focal point. The level of water on the silver objective was 12 mm. Laser beam radius was 3 mm before the focal point and was determined to be 30 μm on the outside of the objective. The volume of the water in the removal was 20 ml and the silver objective was removed with 500 laser beats at various flowability. Tests 1 - 5 were set up with laser beat flowability of 1, 1.5, 2, 2.5, 3 J/cm2 separately. Optical ingestion spectra of specimens in a 10 mm way length quartz cells were estimated by UV-Vis-NIR spectrophotometer from PG Instruments (T-80). (DLS) estimation was finished utilizing the Nano ZS (red identification) ZEN 3600 instrument from Malvern Co, for examining the hydrodynamic size dispersion of the NPs in water. Ordinarily at least 100 particles were needed to find the size dispersion of each example. TEM and SEM micrographs were taken using CM120 and XL30 micrographs facilities PHILIPS Co separately. To quantify the ablation level in the fluid medium, the objective was weighed up by the ablation method by Sartorius Utensil model CP225D with 0.01 mg comprehensibility. After removal inside the water with 500 laser heartbeats, the objective was evaporated and weighed once more. Subsequently, the mass loss of the objective is ascribed to the quantity of created NPs. The authors examined the arrangement of silver NPs by laser removal strategy at various fluencies of the laser beat in unadulterated water. The created NPs in this test condition were practically round. The size of NPs was diminished by expanding the laser beat familiarity and the level of adhesion was diminished and grains were more modest. The density of the abortion top relies upon the laser beat fluence.

Fakhri and Hamza (2013) [73] studied the influence of laser power on optical and morphological characteristics of In2O3 trioxide flimsy film utilizing a deposition by reactive pulsed laser method (RPLD). The optical characteristics of the synthesize incorporate optical microscopic were estimated by optical progress estimation, surface consistency estimation, and FTIR. In the trial methodology, undoped In2O3 slender films were distilled on washed glass backups by utilizing beat Nd: YAG laser statement procedure. Beats of Q-exchanged Nd: YAG laser with(7ns) FWHM and (λ =1.064 nm) were engaged through (10cm) central length of the converging focal point onto a high immaculateness indium object (99.999%) provided by (Fluka com.) at 45_ degree of incidence. The objective was pivoted with a frequency of (0.5Hz). The beat power intensity of the laser at the objective surface was kept up within (100-400 mj/cm2 ). All movies were delivered utilizing (100) laser shots and kept at a substrate temperature of 60Co (this development temperature was ideal) in foundation oxygen pressure (100 mbar). The filmstrips were estimated by a pointer profilometer. The conveyance of the filmstrips were in unearthly reach (200–800) nm utilizing UV-VIS Shimatzu twofold pillar spectrophotometer. The crystal facilities of the developed films were analyzed with FTIR framework (Philips) utilizing CuKa radiation. The morphology of the films was considered by an optical magnifying instrument. The AFM of these filmstrips was contemplated through a Shimatzu (AAXOO) instrument. The creators arranged high straightforward In2O3 slender films effectively using (RPLD). The optical and surface morphology consequences of indium oxide have been explored as an element of laser power. A normal obvious submission of (85%) and an optical band hole of (3.6-3.9) eV was estimated without any post-testimony
heat treatment. The RMS value uncovered the arrangement top notch dainty film with a normal asperity of about (5.97 nm).

Haider (2015) [74] prepared a NC titania powder at room temperature via sol-gel method; using TiCl4 as a precursor and absolute ethanol solution. After mixing, the gel solution was formed. Then the sol-gel was dried and calcined at different temperatures. Nd-YAG pulse laser was used for the ablation method of NPs colloid for minimizing the particle size and get smaller size NPs. Pulse Laser ablation (PLA) was used after the preparation of the nanoparticles colloid. The characterization of the TiO2 NPs in two phases was carried out by X-ray Diffraction (XRD) to investigate the phase structure. The Transmission Electron Microscope (TEM) results show the particle size of NPs after laser ablation less than 10 nm. The results of Scanning Electron Microscopy (SEM) to obtain the surface morphological studies showed that anatase was the only phase in titanium oxide powders of up to 500 °C when the calcination increased in the region of 900 °C the phase transformation from anatase to rutile occurred in the TiO2 nano powders. This paper draws a comparison between the two phases of TiO2 NPs (anatase and rutile). Fourier Transform Infra-Red (FTIR) examines the vibrational frequencies between the bonds of atoms for synthesized TiO2 NPs. The Crystalline size of TiO2 NPs obtained was between (15 -70) nm for anatase at 500 °C and rutile at 900 °C. In FTIR analysis, all the peaks observed were around (400-700) cm-1 due to stretching and bending vibrations.

Al-Dabag et. Al (2015) [75] produced a Zinc Oxide (ZnO) films by (PLD) method at room temperature under the vacancy pressure of 3×10−3 mbar. Employing an Nd: YAG pulses laser at λ 1064nm was used in this technique. In this paper pulse laser deposition (PLD) is utilized to synthesize ZnO thin film. The experimental setup of the Pulsed Laser Deposition (PLD) system consists of a laser source and deposition chamber which includes the target inside it. The substrate, and the vacuum system effect of the number of laser pulses (200,500 and 800) at annealing temperature 450 °C o on the structural, optical, and electrical properties were analyzed. The construct of the ZnO filmstrips was examined by X-Ray diffraction (XRD), and it was found that ZnO thin films are polycrystalline with many peaks. The results of (AFM) indicated that all filmstrips have grain size around 90 nm. The optical properties of the photoluminescence (PL) spectra were analyzed for the prepared filmstrips. Using the PL, the optical space of the ZnO filmstrips was founded. The Hall influence estimations confirmed that the ZnO filmstrips were n-type, while the number of laser pulses increased, the charge carrier’s concentration (n) increased, and Hall mobility decreased. In this work, it was concluded that the structure ZnO thin film polycrystalline must be annealed to 450 Co. and the intensity of peaks increased as No. of pulsed increased from 200 to 800 pulse. The grain size and roughness increased in ZnO thin film as the number of Nd: YAG laser pulse increased.

Mohammed, et.al (2015) [76] produced a TiO2 thin film at room temperature by various densities of CdO of x= (0.0, 0.05, 0.1, 0.15, and 0.2) wt. % into glass backups by pulsed laser deposition (PLD) method using Nd-YAG laser with λ=1064nm, energy=800mJ, with values of shots=500. The structural, morphological, and optical characterizations of as-deposited films were carried out using X-ray diffraction (XRD), atomic force microscopy (AFM), and UV–vis transmittance spectroscopy. The effect of CdO content on these properties was investigated. Characterizations by X-ray diffraction showed a polycrystalline film, with tetragonal structure and formation of the Rutile phase and many peaks (110), (101), (111), and (211) appeared. Besides, AFM instrument proved no cracks in the result layer. The optical characteristics related to the absorption and emission spectra were analyzed for the synthesize filmstrips using an ultraviolet-visible near-infrared spectrophotometer. The results show that the transmittance of the TiO film in the visible domain reached 75%. Optical band gaps were calculated and found to be (3.62, 3.54, 3.45, 3.3 and 3.21) eV for the density of CdO x= (0.0, 0.05, 0.1, 0.15 and 0.2) wt. % separately. At 350 nm the refractive number, extinction factor, and dielectric constant were found. In this paper the auxiliar, morphological, and optical characteristics of TiO2 films distilled by the PLD method were examined. The auxiliary and optical characteristics of the films were studied using XRD, AFM, and UV–Vis-NIR spectrophotometry. The XRD portrayal shows polycrystalline films with the rutile stage. The AFM examinations show no breaks in the film and bigger grains with expanding
centralization of CdO tending to an expansion in the surface asperity. It is seen that the normal grain size increases with expanding focus, with the refractive index, n, and the termination coefficient, in the 200 to 800 nm frequency.

Abd-Alwahab and Rasheed (2015) [77] used Q-switched Nd-YAG laser of λ (1060, 532 and 322 nm) with power in the value of 200 to 1000 mJ and 1 Hz repetition mean to prepare silver NPs through beat laser ablation in fluid. The influence of laser λ has been discussed at first, second and third harmonic generations. The empirical UV-Vis absorbance reading was compared by the theoretical Mie-Gans regime. It is concluded that the lower silver nanoparticle of 12 nm is able to remove Staphylococcus and Streptococcus bacteria. The authors prepared the AgNP’s via PLAL. The empirical procedures for laser ablation of stiff metal object were placed in water or aqueous liquid as seen in figure (13). The Nd-YAG laser beam was concentrated through a lens of 10 cm focus length direct to a metallic object to get power values 10 J / cm2. The laser is supported by facilities on the object at the bottom of the jar as seen in figure (16). The silver sheet was kept in a jar stuffed with 5 ml deionized water. The fluid level was 6 mm over the silver plane. Below the laser ablation technique was introduced, fume - as insoluble over the metal sheet were noted. In this work, the authors concluded that laser ablation of a neat silver sheet in fluid can be used to synthesize silver NPs if right laser properties are utilized. Lessor laser λ produced low silver NPs at smaller focuses. The first laser wavelength (taller wavelength) can be utilized to synthesize higher values with larger focuses. In addition, small laser energy tends to produce higher values of elliptical shape. These NPs have anti-bacterial efficiency towards different kinds of bacteria. It is found that Nd: YAG laser is sufficient to produce silver NPs. The optimum laser factors to prepare lower NPs of 12 nm are laser λ of 355 nm, energy of 400mJ, energy values of 10 j / cm2, and number of beats of 500 pulse. In addition, it is determined that 6 mm fluid thickness over the silver plate introduced best ablation level.

Ismail, et.al (2015) [78] studied the influence of laser flowability on the constructional, morphological, and optical characteristics of CdSe NPs NPs arranged by illuminating a CdSe object, submerged in methanol, with Nd: YAG laser beats at laser flowability in the scope of (1.32–2.92) J/cm2. Xray diffraction XRD estimations revealed that the CdSe NPs were of six-sided polygonal crystal construct. TEM examination uncovered that the incorporated CdSe particles are circular and have a normal molecule size in the scope of (37–94 nm). Microscope SEM and TEM examinations demonstrated that the shape and size of the incorporated CdSe NPs rely upon the laser flowability. The nanoparticles conveyance was connected with laser flowability. AFM examinations demonstrated exceptionally scattered ball-shape CdSe particles. The laser utilized for the ablation is Nd: YAG working at 10 Hz redundancy rate, with 7 ns beat width and λ of 1064 nm. The laser beats were focused by a 20 cm positive focal point onto a washed 2 mm thick CdSe mass example (99.99%) pureness provided from Poch organization) submerged in

**Figure 16.** The experimental setup of the laser ablation process [77]
methanol at different laser flowability (1.32, 1.76, 2.12, 2.51, and 2.92 J/cm²) with an ablation season of 20 min. The optical energy hole of CdSe NPs arranged has been resolved from optical characteristics and found to be in the scope of (1.7–2.05 eV). Optical constants of CdSe NPs were founded from conveyance and reflectance spectra. Hall estimation indicated that the CdSe NPs kinds and their transporter concentration and portability were explored. The optical absorption of colloidal CdSe NPs was estimated utilizing a spectrophotometer in the scope of (200–900) nm. The electrical portrayal was completed utilizing Hall estimations in the wake of introducing ohmic contacts on the CdSe NPs film distilled on a glass substrate by distilling all thick films over an extraordinary cover. The depth of the films was estimated by an ellipsometer. All the above estimations were made at room temperature.

Abd, et.al (2015) [79] synthesized NPs of cadmium sulfide (CdS), monopods, and mounts nanostructures (NSs) by PLD in methanol at various laser flowability absence utilizing a surfactant. The influence of laser flowability on the optical, constructional, morphological, and electrical characteristics of CdS NPs were researched by using UV–Vis spectroscopy, (XRD), SEM, AFM, and Hall estimation. XRD designs show that incorporated CdS NPs are NC and have a six-sided polygonal structure. The continuous optical power space of CdS was discovered between the scopes of (2.5–2.8) eV relying upon the laser flowability. The electrical examination demonstrated that the blended CdS NPs were n-type with portability expanded with laser flowability. Nd: YAG laser (type HUAFEI) working at 1064 nm and 7 ns beat span was used along with a 11 cm positive focal point to remove 99.99 % immaculateness, 1.5 cm breadth CdS pellet. The pellet was set at the lower part of a glass container; containing 5 mL of outright methanol without the expansion of any surface-dynamic substances. The removal cycle was performed at typical weight in the outdoors with laser power of (100–500) mJ per beat and 15 min ablation time. The energy of the laser beat was estimated utilizing Joule meter and aligned to consider the methanol constriction. The laser beam width on a superficial level CdS pellet was estimated by an optical magnifying instrument and discovered to be 2.37 mm. X-beam diffractometer was utilized to examine the structure and crystallinity of NPs. Scanning electron microscope SEM was used to examine the construct of NPs. AFM (AA 3000 filtering test magnifying lens) was applied to consider the morphologyof NPs. The absorption of the colloidal nanoparticle's liquid was estimated by utilizing UV–Vis twofold bar spectrophotometer.

Khumaeni, et.al (2017) [80] prepared great-pureness gold nanoparticles (GNPs) excellently through laser ablation technique employing little energy neodymium yttrium aluminum gemstone (Nd: YAG) laser with basic λ. Empirically, a beat laser beam (Nd: YAG laser, 1064 nm, 7 ns, 30 mJ) was concentrated and concreted with a great pureness gold plate (99.95%), then it was placed with a mere fluid of deionized water, to give GNPs colloid. The dark-red color colloid of maximum pureness GNPs was excellently prepared. The GNPs had a ball-shaped with a mean radius of 11.75 nm and a discrepancy of 6.4 nm. A maximum wave length of 520 nm was centered at the surface plasma resonance. It must be noted that through laser bombardment, the gold plate and liquid were sporadically pushed to give a uniform GNPs colloid and recent-plate place. The GNPs introduced in this work are described by using different processes. The morphology part was achieved through Scanning Electron Microscopy and Energy Diffraction X-ray. The size dispensation of NPs was described through particle size parser and surface plasma resonance was discussed through Ultraviolet-Visible (UV-Vis) light spectroscopy. In this paper, the authors concluded that the pulse laser ablation technique through little-energy Nd: YAG laser is capable of preparing great-pureness (GNPs) in aquades. The GNPs were described through SEM-EDX, particle size parser (PSA), and UV-Vis spectroscopy to pinpoint the morphology, size dispensation, and surface plasmon resonance of GNPs, separately.

Hussein et.al (2017) [81] studied the variance of laser flowability on the constitutional, morphological, and optical characteristics of silver nanoparticles AgNPs arranged through enlightening a silver object, placed in ethanol, using Nd: YAG laser beats with laser flowability at 1.32J/cm². XRD data showed that the Ag NPs were of F.C.C crystal construct. AFM instrument indicated that the prepared nanoparticles of Ag are ball-shaped with mean particle size between (40-50 nm). The optical power space of Ag NPs arranged has been founded from optical characteristics and gained to be in the scope of 1.95 whereas
optical factors of Ag NPs were founded by submission and reflectance spectra. The published paper shows the influence of the fluid on constitutional, optical, and morphological characteristics of Ag NPs arranged using laser ablation. In this paper, it was indicated that the manufacturing of Ag NPs in ethanol using laser ablation introduced firstly. The production of NPs was polycrystalline with the FCC phase. The optical characteristic information discovered that the continuous optical strip gap of silver ablated in ethanol was 1.95 eV.

Algburi, et.al, (2018) [82] produced silver nanoparticles AgNPs by physics method using the Q-switched Nd-YAG laser of a silver nitrate aqueous solution (AgNO3). The AgNPs were characterized using a UV-VIS spectrometer and Scanning Electron Microscope (SEM). An aqueous solution of AgNO3 at concentrations of (2, 6, and 8 mM) was prepared. These levels were used in the synthesis of the (AgNPs). All the chemicals used in the investigation were as follows: minimum assay (on dried material, India): 99%, chloride (Cl): >0.001%, sulphate (SO4): >0.01%, iron (Fe): >0.001%, lead (Pb): >0.002%, and substances not precipitated by hydrochloric acid (as Sulphate): >0.01%. The Nd-YAG laser beam was focused on the silver solution in a vessel container of 2 mL. Q-switched Nd-YAG laser provides pulses of 532 nm and 1064 nm wavelength with max energy per pulse of about 700 mJ. It has the pulse duration of 10 ns, the pulses counter= 30, temperature range equal to 19° -23°, the repetition rate of 5 Hz, and a useful beam diameter of 5 mm used. The change of silver solution color within a few minutes was produced. The color of solutions started to change to faint yellow during an ablation process because the silver NPS is yellow. The optical properties (absorbance spectra) of NPs colloidal solution were measured using a spectrophotometer at range of 200 nm to 1100 nm. All spectra were estimated within 25 degree temperature in the quartz cell of 1 cm optical depth. The spectrophotometer was used in the quantitative determination and sometimes was used in qualitative diagnosis. All the spectra exhibit the characteristic peaks around 400 nm, indicating the silver colloid formation. The diameter and investigation of the AgNP were determined using SEM images. An SEM is a type of electron microscope that images a specimen by scanning it with an electron beam in the raster scan pattern. The electron has interacted with an atom that makes sample producing signals containing data about the specimen surface topography, composition, and electrical conductivity. Atomic absorption spectroscopy was used for the absorption spectra of AgNPs. The authors concluded that the advantages of using YAG laser in the synthesis of Ag NPs are environmentally friendly.

Alnayli and Alkazaali (2019)[83] synthesized silver nanoparticles (Ag NPs) by pulsed laser ablation by using (Q-switched Nd: YAG) pulse duration10ns and (E=80mJ, λ=532nm). The silver metal was targeted in deionized water and ethanol pulsed laser ablation of the silver object in deposition water, and ethanol at temperature of 25 degree. The silver object (pureness of 99.99%) was supported at base of the glass vessel including 2 ml of duple- imbued deionized water DDDW. The ablation was achieved using the focused output of pulsed Nd: YAG laser operating with a repetition rate of 6 Hz and a pulse width of 10 ns. Ablation was carried out with laser operating at (E=80mJ, λ=532nm), the quantity of laser stroke was affected by the metal objective at (100,200,300) pulse. Size and shape measurements were investigated by XRD and AFM. The consequences of XRD clarify that no debasement was found in diffraction tops in the pattern and Ag NPs have top quality type of crystalline, which indicates the presence of silver particles with FCC structure. The optical properties were studied with Ultraviolet Visible (UV-Vis) spectrophotometer which showed blue-shaft with pulse number, and an atomic force microscope (AFM) indicating the size in nanometer (nm) range of about (40-80)nm. The authors concluded that Ag thin films are polycrystalline. The AFM images showed that the number and particle distribution increases with increase in the number of pulses, and the average diameter range was (40-80) nm.

Alhamid, et.al (2019)[84] synthesized silver NPs using a pulse laser ablation strategy. Tentatively, a great pureness silver sheets (99, 95 %) were inundated in 25 ml unadulterated aquades put in a petri dish with a distance of 50 mm. Pureness of 99.95% silver sheets were cleaned utilizing alcohol to eliminate microorganisms and other bacteria. At that point, the 99,95% unadulterated silver plate was added to the vessel obscure by 20 ml of colloid refined water. A beat (Nd: YAG) laser with (λ of 1064 nm and
maximum power of 50 mJ, and pulses number of 7 ns) was centered around the gold specimen object by an arched focal point with a central length of 30 mm. The laser replication ratio was 10 Hz, and the span of the laser siege was 13 hours. During the shoot procedure, the petri dish containing silver specimens was moved gradually and ceaselessly to get equally appropriated NPs colloids. The results show that colloidal silver NPs have a yellowish collar. Moreover, the prepared silver NPs have a ball shape with mean diameter size of tens nm.

6. Conclusion
In this paper, the development of NPs production using different laser techniques are reviewed. It can be concluded that the laser techniques such as pulsed laser deposition (PLD), Nd-YAG Pulse Laser Ablation (PLA), and (PLAL) are very good methods to produce nanoparticles with suitable optical and morphological properties. The authors focused on three parts in their work. The first part of reviewed papers the researchers dealt with the techniques used in the synthesis of nanoparticles which are solid crystal, gas, semiconductor junction, or liquid. In the gas laser techniques, gas atoms are used as the active medium. In the solid-state laser techniques, a solid crystalline rod containing the lasing atoms is used as the active medium. The most common type of solid state laser is the Nd:YAG laser.

In the second part of the reviewed papers, the researchers studied the optical and morphological characteristics. The processes of optical characterization were employed to gather data on NPs reflectivity, absorption, luminescence and phosphorescence characteristics. To study the morphological properties of the nanoparticles materials, the NPs can be classified into four material-based categories which are (i) Carbon-based nanomaterials, (ii) Inorganic-based nanomaterials, (iii) Organic-based nanomaterials, and (iv) Composite-based nanomaterials. Nanoparticles and nanostructured materials can be synthesized by different morphologies based on the needed characteristics for the desired application.

Finally, in the last part of reviewed papers, the authors focused on the instrument and testing method used to find the optical and morphological properties which are X-ray diffraction (XRD) patterns, scanning electron microscope (SEM), atomic force microscope (AFM), Fourier Transform Infra-Red (FTIR), Scanning Electron Microscopy – Energy Diffraction X-ray (SEM-EDX), and UV-Visible spectrum analysis.

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