Use of the µPIV technique for an indirect determination of the microchannel cross-section passage geometry

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Abstract. In this work the possible use of the µPIV technique for the experimental determination of the microchannel cross-section geometry has been investigated by means of a blind test in which a series of experimental measurements obtained using glass microchannels having a declared rectangular cross-section with a depth of 100 µm and width of 300 µm and a square microchannel with a 300 µm side have been compared with the direct SEM visualisation of the real cross section of the microchannels. For the µPIV measurements water is used as working fluid. The laminar fully developed 2D velocity profile has been reconstructed by moving the focal plane of the microscope objective from the bottom to the top of the microchannel. The results shown in this paper demonstrate that the real cross section geometry of the microchannel can be predicted by minimizing the difference between the theoretical and the experimental 2D velocity profiles. When the right passage geometry is determined, the average difference between the theoretical and the experimental velocity is within 4-6%.

1. Introduction
Starting from the first successful experiment made by Santiago et al. in 1998 [1], Micro Particle Image Velocimetry (µPIV) has assumed an increasing importance for the determination of the velocity profile of liquid flows through micro-passages becoming nowadays the most employed technique [2, 3, 4] for the analysis of liquid velocity field in microdevices. An updated and critical review about the progress of the µPIV technique was made by Lindken et al. [5].

Zheng and Silber-Li [6] have shown how the µPIV technique can be used to reconstruct the 2D velocity profile within a rectangular microchannel having a height of 19.1 µm and a width of 54 µm. The tested microchannel was fabricated using the soft-lithography technique on hydrophobic PDMS and then bonded on a hydrophilic glass substrate. They measured the velocity profile in 14 horizontal planes along the vertical direction of the microchannel at \( Re = 1.8 \) and \( Re = 3.6 \). They demonstrated that, except for the profiles adjacent to the upper and lower walls, the experimental data obtained are in good agreement with the theoretical profiles. The relative deviations they were able to achieve between experimental data and theoretical values in each horizontal plane were always less than 3.6%.

The high accuracy obtainable with the µPIV technique when laminar flows at low Reynolds numbers are considered has suggested the use of the µPIV as an indirect technique for the determination of the cross section of a micropassage. Silva et al. [7], starting from the 2D

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reconstruction of the velocity field in a microchannel, have suggested an indirect method in order to determine the shape and the dimensions of a microchannel by searching iteratively the cross section which minimizes the difference between the volumetric flow rate supplied by means of a syringe pump and the volumetric flow rate yielded by the integration of µPIV velocity profiles.

Starting from the original idea of Silva et al. [7] in this work the use of the µPIV technique for the prediction of the microchannel cross-section geometry has been deeply investigated by means of a series of experimental measurements obtained using two different glass microchannels. At the end of the experimental campaign, the real cross section of the microchannels has been determined by means of destructive tests using a SEM visualisation and a comparison with the predictions obtained by using the µPIV measurements is shown.

2. Experimental Apparatus

The µPIV apparatus used in this work is composed by a pulsed Nd:YAG (λ = 532 nm) monochromatic laser (1) (NanoPIV, Litron Lasers): the laser emits two pulses with a duration of each pulse of the order of 5 ns and a time delay between light pulses variable from hundreds of nanoseconds to few seconds.

![Figure 1. Lay-out of the µPIV experimental apparatus.](image)

The illumination light is delivered to the inverse microscope (EclipseT2000, Nikon) (3) through beam-forming optics (2), which consists of a variety of optical elements that sufficiently modify the light so that it fill the back of the objective lens and thereby broadly illuminate the microfluidic device. The illumination light is reflected upward towards the objective lens by an antireflective coated mirror designed to reflect wavelength 532 nm and transmit 560 nm (4). An air immersion lens (5) with a numerical aperture NA = 0.75 and magnification M = 20 is used. A sensitive large-format interline-transfer CCD camera (1376 x 1040 pixels) (Sensicam, PCO) (9) is used to record the particle image fields. The interline transfer feature of the CCD camera allows for two image frames to be recorded back-to-back within a 500 ns time delay.

Fluorescent seeding (Invitrogen, FluoSphere) is dispersed in the working fluid (water). The particle tracer presents a diameter of 1.0 µm, orange coloration, a carboxylate coating and emitting a radiation wavelength of 560 nm when it is illuminated with a green light (λ = 532 nm). The seeded working fluid is contained in a syringe (Hamilton Gastight #1010) (7) of 10.0 ml volume. The pressure required to flow the fluid within the microchannel (6) is delivered by a syringe pump (Harvard Apparatus PHD 4400) (8). A Dantec synchronization unit (10) connected with the laser, the CCD camera and a computer (11), guarantees the tuning between the light pulse and the acquisition of the images. The right illumination intensity of the laser beam is set from a remote control (12). With this configuration the depth of correlation DOC,
2.1. Mixture preparation.

The concentration $C$ of the tracer within the working fluid is calculated as ratio between the total volume of the seeding ($V_{p,\text{tot}}$) and the total volume of solution ($V_{\text{sol}}$):

$$ C = \frac{V_{p,\text{tot}}}{V_{\text{sol}}} $$

(1)

In this case $V_{\text{sol}}$ has been approximated with the volume of working fluid since the volume of tracer is in the order of few microliter, five order of magnitude lower than the volume of the working fluid. $V_{p,\text{tot}}$ can be calculated as:

$$ V_{p,\text{tot}} = \frac{4}{3} \pi N \left( \frac{d_p}{2} \right)^3 $$

(2)

Herein, $N$ is the total number of tracer particles within the working fluid and $d_p$ is the particle diameter. The total number of tracer particle $N$ is given by:

$$ N = n_p c $$

(3)

where, $n_p$ is the number of microsphere per volume of aqueous suspension (usually expressed in particles per ml) and $c$ is the volume of aqueous suspension. The values of $c$, $N$, $V_{p,\text{tot}}$, $V_{\text{sol}}$ and $C$ used during the experimental tests described in this paper are given in table 1.

### Table 1. Seeding characteristics and tracer concentration used in the tests.

| $d_p$ (µm) | $n_p$ (2.7x10^9 particles/ml) | $c$ (µl) | $V_{p,\text{tot}}$ (µl) | $V_{\text{sol}}$ (ml) | $C$ (ppm) |
|---|---|---|---|---|---|
| 1.0 | 2.7x10^9 | 25 | 0.35 | 10 | 35.33 |

$^a$ LI is the tracer wavelength absorption  
$^b$ LE is the tracer wavelength emission

2.2. Microchannels

In this work two different commercial glass microchannels (Translume) have been used. The first one presents a declared rectangular cross-section with a depth of 100 µm and width of 300 µm. The second one has a declared square cross-section with a side of 300 µm. The two straight microchannels have the same length (38 mm). Both microchannels are made by laser etching on a substrate of high quality fused silica and then bonded with the same material. The roughness of the inner walls is declared to be <0.1% by the manufacturer.

3. Theoretical determination of the velocity field

For the determination of the theoretical velocity field within a microchannel, let’s consider a steady state, forced laminar, hydro dynamically fully developed flow in a duct with constant cross-section in the motion direction. Three assumption have been made: i) the fluid is Newtonian and its physical properties are constants along the whole duct; ii) natural convection is negligible and the flow can be considered as isothermal; iii) the pressure gradient is constant along the flow direction. Under these conditions and considering an orthogonal Cartesian system $(x,y,z)$, the dimensionless momentum Navier Stokes equation can be written [8]:

$$ \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial z^2} + \tilde{P}_d = 0 $$

(4)
where the following dimensionless parameters are used:

\[ \tilde{x} = \frac{x}{L_{ch}} \quad \tilde{z} = \frac{z}{L_{ch}} \quad \tilde{V}(\tilde{x}, \tilde{z}) = \frac{v(x, z)}{W_{avg}} \quad \tilde{p}_d = \frac{D_p^2}{\mu} \frac{\partial p_d}{\partial \tilde{y}} \]  \hspace{1cm} (5)

Herein, \( L_{ch} \) is the width of the channel (long side) and taking \( H \) as the height of the channel (short side) is possible to define the aspect ratio \( \beta = \frac{H}{L_{ch}} \).

\( v(x, z) \) is the dimensional value of the velocity, \( W_{avg} \) is the average velocity of the working fluid on a cross section of the channel and \( \frac{\partial p_d}{\partial \tilde{y}} \) is the pressure drop over the flow direction. The differential problem is closed by the boundary conditions, which in this case coincide with the no-slip conditions at the walls (the glass has not undergone to hydrophobic treatment).

\[ V(0, \tilde{z}) = V(1, \tilde{z}) = 0 \quad V(\tilde{x}, 0) = V(\tilde{x}, \beta) = 0 \]  \hspace{1cm} (6)

For ducts with a rectangular cross-section, the analytical solution of equation (4) with no-slip conditions at the walls is the following (Morini [9]):

\[ V(\tilde{x}, \tilde{z}) = \sum_{n=1, \text{odd}}^{\infty} \sum_{m=1, \text{odd}}^{\infty} \nu_{n,m} \sin(n\pi \tilde{x}) \sin\left(\frac{m\pi \tilde{z}}{\beta}\right) \]  \hspace{1cm} (7)

where the series coefficients \( \nu_{n,m} \) are defined as:

\[ \nu_{n,m} = \frac{\pi^2}{4mn(\beta^2 n^2 + m^2)} \left( \sum_{j=1, \text{odd}}^{\infty} \sum_{k=1, \text{odd}}^{\infty} \frac{1}{j^2 k^2 (\beta^2 j^2 + k^2)} \right)^{-1} \]  \hspace{1cm} (8)

For geometries different from the rectangular, equation (4) must be solved numerically. In this work the solution of equation (4) has been obtained by using FlexPDE.

In order to compare the theoretical profiles with the experimental data the dimensionless velocity must be multiplied by the average velocity which can be obtained as ratio between the volumetric flow rate imposed by means of the syringe pump \( (Q) \) and the cross-section area, \( (S_{cs}) \):

\[ v(x, z) \frac{Q}{S_{cs}} = V(\tilde{x}, \tilde{z}) W_{avg} \]  \hspace{1cm} (9)

4. Experimental procedure

The first step of the experimental procedure is the determination of the upper and lower wall position of the microchannel. Due to the adherence of the tracer particles to the wall it is possible to individuate the position of the walls by checking the fluorescent particles attached on the wall varying the focal plane by means of the microscope. Moving upwards and downwards the objective focal plane, it can be found the plane where the particles appears as fixed. When these particles, visible as stable bright points, are detected it means that a microchannel wall is actually on focus. Starting from the lower wall assumed as a reference point for the reconstruction of the real cross section of the channel, the objective focal plan is shifted upward in order to determine the position of upper wall of the channel. The displacement found from the movement of the focal plane between the lower and the upper wall is generally different from the real depth of the microchannel due to the refraction index of the working fluid (water, \( i.e. \ n_w = 1.333 \)). As stated by Lindken et al. [5], to achieve a proper experimental investigation, the operating parameters, such as the time interval \( \Delta t \) between the image pair, the size of interrogation area and the flow rate, must be consistent with each other. The settings of these parameters has been done in order to satisfy two conditions: i) the displacement of the fluorescent particles at the maximum velocity does not exceed \( \frac{1}{4} \) of the interrogation cell width; ii) at least five particle pairs must be present into each interrogation cell. The setting of the main operative parameters is shown in table 2.
Table 2. Value of the parameters set.

| Microchannel | Declared size of the microchannel (µm x µm) | Time interval between the image pair (µs) | Size of interrogation area (overlap) (pixel x pixel) | Flow rate (m³/s) |
|--------------|--------------------------------------------|------------------------------------------|------------------------------------------------|-----------------|
| #1           | 100x300                                    | 50                                       | 64x64 (50%)                                              | 5.6 x10⁻¹⁰     |
| #2           | 300x300                                    | 50                                       | 64x64 (50%)                                              | 2.22 x10⁻⁹     |

The images were acquired in grayscale and then filtered to obtain an high contrast value between the tracer particle and the background, as seen in figure 2. A series of 500 images, for each different plan, has been elaborated in order to avoid the influence of the Brownian motion and other unwanted stochastic micro-effects on the reconstruction of the velocity profiles. For each plane, a vector map containing 40 column of 28 velocity vectors is obtained applying an average cross-correlation among the 500 pairs of images.

Figure 2. Image of the fluorescent particles after the filtering

Figure 3. Vector map of the flow field in an horizontal plan

To perform the matching between the experimental data and the theoretical velocity profiles determined by solving equation (4), the velocity, expressed in pixels per unit time, determined by means of µPIV is converted in meters per second in the following way:

\[ u(x,z) = \frac{s_{pix}L_{ch}}{\Delta L_{pix}} \]

where \( u(x,z) \) is the dimensional velocity, \( s_{pix} \) is the displacement in pixels of the bright point between the two images, \( \Delta t \) is the time interval between the two images, \( L_{ch} \) is the width of the channel in meters and \( L_{pix} \) is the width of the channel in pixels. The velocity uncertainty has been estimated to be equal to 3% by using the following equation:

\[
\frac{\Delta u}{u} = \left( \left( \frac{\Delta s_{pix}}{s_{pix}} \right)^2 + \left( \frac{\Delta L_{ch}}{L_{ch}} \right)^2 + \left( \frac{\Delta L_{pix}}{L_{pix}} \right)^2 \right)^{1/2}
\]

where \( \Delta s_{pix} \) has been assumed of 0.1 pixel [7], \( \Delta L_{ch} \) has been taken of 1 µm and \( \Delta L_{pix} \) has been estimated to be of the order of 13 pixels in these experiments. The relative error on the time delay \( \Delta t \) has been neglected in equation (11) because the uncertainty on it is several orders lower than the value of the same.
5. Experimental results and discussion

As shown in figure 4, for the geometry reconstruction of the 2D velocity profile, P different planes have been used (7 for the rectangular channel and 11 for the square one). These planes have been acquired starting from the central plane (p=4 for the channel #1 and p=6 for the channel #2) with an increasing distance of ± 13.65 µm for the channel #1 and 27 µm for the channel #2. The displacements have to be considered as the real distance between the different planes, i.e., the refraction index has already been taken into account. The vertical displacement of the focus plane has an accuracy of 1 µm that corresponds in an accuracy of 1.33 µm on the vertical localization of the plane. For each plane, a vector map containing $N_v = 40$ columns of $M$ velocity vectors is made (see figure 3). Since the flow is in steady-state conditions, each column of velocity vectors contains the same information. It is possible to select one column of vectors among the $N_v$ columns associated to a fixed plane $p$, choosing the one who results from the optimization of the normalized root mean square error over the plane:

$$
e_p = \min \left( \frac{1}{M} \sum_{m=1}^{M} \left( \frac{u_{p,m} - v_{p,m}}{v_{p,m}} \right)^2 \right)$$

Herein $u_{p,m}$ is the experimental velocity vector in the $m$-th position of the $n$-th column on the plane $p$, and $v_{p,m}$ is the value of the theoretical velocity (calculated by using equation (7) for a rectangular cross-section) in the $m$-th position of the plane $p$.

With this method, for each plane $M$ velocity vectors have been determined: in particular, 28 velocity vectors both for the rectangular and square geometry have been associated to the interrogation cells used to divide the field-of-view. In this way a 2D velocity field made by $P \times M$ points (7x28 for microchannel #1 and 11x28 for microchannel #2) has been determined.

Varying the aspect ratio of the rectangular microchannel's cross-section from which the theoretical curves have been obtained the relative error between the experimental and numerical velocity changes. Therefore it can be deduced that the relative difference $e_p$ defined by equation (12) can be considered as a function of the geometric shape of the cross-section [7].

In figure 5 the comparison between the experimental values of velocity determined by μPIV measurements and the theoretical profiles determined by using equation (7) and equation (9) for microchannel #1 (a,b,c) and #2 (d,e,f) is shown. The experimental data are shown in figure 5 with the corresponding error bars for three different planes: plane 4 and plane 6 correspond to the central plane of the microchannel #1 and #2 respectively (see figure 4 and table 3 and 4). Plane 6 and 2 are far +27 µm and - 27 µm respectively from the central plane of microchannel #1. Plane 9 and 3 are far +81 µm and - 81 µm respectively from the central plane of the microchannel #2. The experimental data are in good agreement with theoretical profiles for the upper planes, both for microchannel #1 and #2. On the contrary, when it gets close to the bottom wall, the matching between the theoretical and the experimental values became worse and the relative difference $e_p$ grows up, as it has been reported in the first column of table 3 and table 4 for microchannel #1 and #2 respectively.
It is possible to observe that the relative difference $e_p$ varies for microchannel #1 from a value of 5.0% on the central plane up to 11.2% on the plane close to the upper wall and 15.4% on the plane close to the bottom wall, reaching the minimum value of 4.6% on the planes 6 and 5. For microchannel #2 the relative difference is in between 3 and 6% in the central part of the microchannel and it grows up to 9.6% and 15.0% close to the upper and bottom wall respectively. This result can be explained by considering the following aspects:

1. the μPIV technique gives accurate velocity profiles when the focal plane drops in the central part of a microchannel, as evidenced by Zheng and Silber-Li [6]; on the contrary, when the focal plane is moved close to the bottom wall of the channel the velocity determination becomes more difficult due to the combined effect linked to the influence of the larger velocity gradients on the seeding particles and the reduced quantity of light collected on the focal plane when the water thickness increases.

2. The real geometry of the microchannel is not exactly rectangular as declared by the manufacturer but the width of the channel changes by decreasing from the upper wall to the bottom wall of the microchannel.

In order to exclude the first hypothesis, the measurements have been repeated by increasing the number of particles and the quantity of light collected on the focal plane by increasing the laser power but the experimental data have confirmed the previous results. With the aim to verify the second hypothesis, as suggested by Silva et al. [7], the μPIV experimental data have been used to predict the cross section of a microchannel by minimizing the value assumed by the relative difference $e_p$. In fact, $e_p$ can be considered as a function of the cross-section geometry of the microchannel; by changing the microchannel geometry one can modify the theoretical velocity profile by solving numerically equation (4) and the relative difference $e_p$ varies as consequence for a fixed set of experimental data. The value of the relative difference $e_p$ has been determined by considering the cross section as trapezoidal with a value of the apex angles between the upper wall and the inclined side equal to $\theta_{lf}$ and $\theta_{rg}$ on left and right side respectively (see figure 4). The values of $e_p$ obtained for each plane by varying $\theta_{lf}$ and $\theta_{rg}$ from 90° to 84° are reported in table 3 and table 4 for microchannel #1 and #2 respectively.
Table 3. Relative error as a function of the cross-section of microchannel #1 (300x100 µm)

| Plane, p [#] | z [µm] | Relative error e_p [%] for different θlf and θrg [°] |
|-------------|--------|-------------|
| 7           | 90.9   | 90/90       | 98/98       | 97/97       | 96/96       | 95/95       | 94/94       |
| 6           | 77.3   | 4.6         | 4.4         | 4.6         | 4.8         | 5.2         | 5.7         |
| 5           | 63.6   | 4.6         | 4.3         | 4.2         | 3.9         | 4.1         | 4.7         |
| 4           | 50     | 5.0         | 3.4         | 2.6         | 2.3         | 2.5         | 4.4         |
| 3           | 36.4   | 4.7         | 4.5         | 2.8         | 2.3         | 2.8         | 3.1         |
| 2           | 22.7   | 6.1         | 5.0         | 4.1         | 3.9         | 3.7         | 4.1         |
| 1           | 9.1    | 15.4        | 11.0        | 11.3        | 11.3        | 10.8        | 10.8        |

\( e_{\text{avg}} [\%] \)

7.4, 6.3, 5.9, 5.7, 5.8, 6.2, 6.9

Table 4. Relative error as a function of the cross-section of microchannel #2 (300x300 µm)

| Plane, p [#] | z [µm] | Relative error e_p [%] for different θlf and θrg [°] |
|-------------|--------|-------------|
| 10          | 258    | 90/90       | 99/99       | 98/98       | 97/97       | 96/96       | 95/95       |
| 9           | 231    | 2.8         | 3.5         | 4.3         | 5.9         | 7.9         | 9.1         |
| 8           | 204    | 2.3         | 2.0         | 2.7         | 4.4         | 6.5         | 8.4         |
| 7           | 177    | 2.8         | 1.0         | 1.7         | 3.5         | 5.7         | 6.5         |
| 6           | 150    | 4.2         | 1.8         | 1.2         | 2.6         | 5.4         | 6.3         |
| 5           | 123    | 4.2         | 2.9         | 1.1         | 1.9         | 4.2         | 6.3         |
| 4           | 96     | 5.9         | 3.9         | 2.3         | 1.2         | 3.2         | 5.9         |
| 3           | 69     | 7.8         | 5.7         | 4.0         | 2.1         | 1.6         | 4.0         |
| 2           | 42     | 15.0        | 12.2        | 9.4         | 6.9         | 5.3         | 3.3         |

\( e_{\text{avg}} [\%] \)

6.1, 4.8, 4.2, 4.4, 5.8, 7.0

The values quoted in table 3 and 4 demonstrate that for each microchannel there exists a specific combination of θlf and θrg which minimize the average value of the relative difference between the numerical and experimental velocity field defined as follows:

\[
e_{\text{avg}} = \frac{\sum_{p=1}^{P} e_p}{P}
\]

where P is the number of planes used for the determination of the velocity profiles through the microchannel (7 for microchannel #1, 9 for microchannel #2, see figure 4).

In table 4, the results obtained for the planes 1 and 11 have not been reported because it was felt they have not physical substance, therefore the average error \( e_{\text{avg}} \) on the section has been calculated over 9 floors instead of 11.

By observing the data quoted in table 3 and 4 it is evident that the experimental data seem to indicate that the microchannels have a trapezoidal cross section characterized by a decreasing width from the upper wall to the bottom wall. In fact, it is possible to observe that the cross section geometry which minimize the average relative difference between theoretical and experimental values is the trapezoidal geometry with \( \frac{\theta_{\text{lf}}}{\theta_{\text{rg}}} \) equal to 87°/86° for microchannel #1 and 88°/88° for microchannel #2. By selecting for the microchannels these two cross sections the
relative difference $e_p$ decreases from 15.4% down to 11.3% on the plane close to the bottom wall of the microchannel #1 and, more important, this value becomes similar to the value obtained on the plane close to the upper wall. The same result is obtained for microchannel #2 where $e_p$ decreases from 15.0% to 9.4% on the plane close to the bottom wall.

As an example, in figure 6, the comparison between the experimental data obtained for microchannel #2 and the theoretical velocity profiles obtained by imposing the angles $\theta_{lf}/\theta_{rg}$ equal to 88°/88° which minimize the average value of the relative difference $e_{avg}$ is shown on the planes 3 (close to the bottom wall), 6 (central) and 9 (close to the upper wall). It is evident that in this case the agreement between theoretical and experimental values is strongly increased and the difference is on each plane within the experimental uncertainty.

![Figure 6](image.png)

**Figure 6.** Matching between experimental data and theoretical velocity profiles for microchannel #2 on plane 9, 6 and 3 for $\theta_{lf}/\theta_{rg}$ equal to 88°/88°.

In order to verify the real cross section of the tested microchannels, the glass microchannel #2 has been submitted to destructive tests by means of which several samples, prepared with an LKB 7800 knife maker and then coated with a golden layer, have been obtained to visualize the real channel cross section by means of a SEM microscope (Philips SEM EM 515). In figure 7 a SEM image of the cross-sectional area of microchannel #2 with a magnification of 14x is shown. In figure 8 the same image of the cross-section has been taken with a magnification of 212x. As it is possible to see from figure 8, the shape of the cross-section is not perfectly squared, as declared by the manufacturer, but presents a trapezoidal shape in agreement with the indications of the µPIV measurements. In addition figure 8 highlights that the upper side of the microchannel presents a curvature which was not taken into account in this analysis and it can be responsible of the residual deviation of the experimental values of velocity from the theoretical ones. In table 5 are summarized the geometrical features of the microchannel #2 in terms of ratio between the upper and lower wall ($L_u$ and $L_b$) and the depth (H) of the microchannel and in terms of apex angles.

| Microchannel | $L_u/H$ [-] | $L_b/H$ [-] | $\theta_{lf}/\theta_{rg}$ |
|--------------|-------------|-------------|---------------------------|
| #2           | Experimental| Predicted   | Experimental              | Predicted   | Experimental | Predicted   |
|              | 1           | 1           | 0.91                      | 0.93        | 87.5°/87.5°  | 88°/88°     |

By observing the data reported in table 5 it is possible to conclude that the real data confirms the predictions obtained by using the µPIV velocity profiles and in particular the SEM measurements have confirmed that the real cross section of the microchannel #2 is slightly trapezoidal with an apex angle of 88° in disagreement with the indication of the manufacturer. These results confirm that µPIV measurements can be used as non-destructive test for transparent channels in order to predict the real geometry of a unknown micro-passage.
6. Conclusions
In this work the μPIV technique has been used in order to determine the shape of a micropassage starting from the reconstruction of the 2D velocity field within the channel. It has been shown how the average difference between the theoretical and experimental velocity profiles is a function of the cross section geometry and the minimisation of this parameter, obtained by changing the shape of the micropassage, allows the individuation of the geometrical characteristics of the cross section. The results obtained by using this method have been compared with the indications, obtained by means of destructive tests, based on a SEM visualization of the real cross section of the tested microchannels: the SEM visualizations confirmed that the real cross section of the microchannel #2 is slightly trapezoidal with an apex angle of 88° in disagreement with the indication of the manufacturer and in agreement with the predictions obtained by using the μPIV measurements and the procedure described in this paper. These results confirm that μPIV measurements can be employed to predict the real geometry of a unknown micro-passage avoiding the use of destructive test methods.

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