Figure S1. Image projection results of the diffractive PSR display using complex-valued image encoding. Top: Image projection results of the PSR display using 5 diffractive layers (L=5). Middle row: Image projection results of the PSR display using 3 diffractive layers (L=3). Bottom: Image projection results of the PSR display using 1 diffractive layer (L=1). For comparison, low resolution versions of the same images are illustrated on the right side of the figure.
Figure S2. Image projection results of the diffractive PSR display using an amplitude-only SLM. Image projection results of the PSR display using 5 diffractive layers (L=5). For comparison, low resolution versions of the same images using the same number of pixels as the corresponding wavefront modulator are illustrated on the right side of the figure.
Figure S3. Image resolution analysis of the diffractive PSR display using complex-valued image encoding. Projections of vertical and horizontal line-pairs with a linewidth of 2.132\(\lambda\) are tested under different PSR factors (k = 4, 6, and 8). Diffractive all-optical decoders with different numbers of diffractive layers (L = 1, 3, and 5) project super-resolved images at the output FOV. For comparison, low resolution versions of the same images are illustrated on the right side of the figure. The diffractive PSR systems were trained using handwritten letters and the training dataset did not include any resolution test targets or line pairs.
Figure S4. Performance of the diffractive PSR display on a different test dataset. Image projection results of the diffractive PSR display on different types of input images compared to the training dataset (EMNIST display dataset) are shown to illustrate its generalization capability. For this analysis, we used different sets of handwritten test digits (MNIST) to show the image projection results of the same 5-layer diffractive PSR display systems (used in Fig. 2 of the main text) for achieving super-resolution factors of $k=4$, $k=6$, and $k=8$. For comparison, low resolution versions of the same images using the same number of pixels as the corresponding wavefront modulator are illustrated on the right side of the figure.
Figure S5. Phase quantization analysis of diffractive decoders for PSR image projection. Image projection results of the diffractive PSR display (k = 4) using 5 diffractive layers (L=5) are demonstrated for different phase quantization levels at each diffractive layer (i.e., 16-, 8-, 6-, 4-, and 2-bit). The encoder-decoder framework was trained using 16-bit phase quantization of the diffractive decoder layers and then blindly tested for lower quantization levels at the resulting diffractive layers. a) Output images for different phase quantization levels of the diffractive layers. b) Average PSNR and SSIM values of the diffractive PSR display as a function of the phase quantization level of the diffractive layers.
Figure S6. The impact of phase noise at the SLM pixels for PSR image projection. Image projection results of the 5-layer PSR display ($k = 4$) using a phase-only SLM are demonstrated for different amounts of phase noise added to each SLM pixel; the phase noise is characterized by $w_{\alpha}[m,n] = \alpha \times U[m,n]$, where $U[m,n]$ refers to a uniform random variable between $-\pi$ and $\pi$, independently generated for each SLM pixel $[m,n]$. The encoder-decoder framework was trained without any noise (unvaccinated) and blindly tested for different noise levels (i.e., $\alpha = 0.025$, $0.05$, $0.1$, $0.2$). For comparison, the same framework was also trained using a random noise level of $\alpha = 0.06$, forming a vaccinated diffractive decoder, which was also blindly tested with different levels of random phase noise. a) Image reconstructions of the unvaccinated
and vaccinated diffractive PSR displays at different noise levels. b) Average PSNR and SSIM values of the unvaccinated and vaccinated diffractive PSR displays at different noise levels. c) Diffractive layers of the all-optical decoders of the unvaccinated and vaccinated PSR displays.

Figure S7. Lateral and axial vaccination analysis of diffractive PSR image decoders (5 diffractive layers and a phase-only SLM). For the lateral misalignments of each diffractive layer of the PSR decoder,
uniformly distributed random variables, $U(-v_{\text{tr},x}, v_{\text{tr},x})$ and $U(-v_{\text{tr},y}, v_{\text{tr},y})$, are used for \( x \) and \( y \) directions, respectively, during the training phase; this way all the diffractive layers of the decoder are laterally misaligned in each batch of the training. Maximum possible misalignment amount is assumed to be same for both \( x \) and \( y \) directions, i.e., $v_{\text{tr},x} = v_{\text{tr},y} = v_{\text{tr},\text{lat}}$. For the axial misalignments of each diffractive layer, a uniformly distributed random variable $U(-v_{\text{tr},ax}, v_{\text{tr},ax})$ is similarly utilized during the training phase.

a) Results of the unvaccinated PSR diffractive image display with perfect lateral alignment ($v_{\text{tr},\text{lat}} = 0$) are compared against the vaccinated PSR diffractive image displays trained with different amounts of lateral misalignments, i.e., $v_{\text{tr},\text{lat}} = 0.1\lambda$, $0.3\lambda$, $0.5\lambda$ and $0.7\lambda$. b) Results of the unvaccinated PSR image display with perfect axial alignment ($v_{\text{tr},\text{ax}} = 0$) are compared against the vaccinated PSR diffractive image displays trained with different amounts of axial misalignments, i.e., $v_{\text{tr},\text{ax}} = 0.1\lambda$, $0.3\lambda$, $0.5\lambda$ and $0.7\lambda$. All the unvaccinated and vaccinated models are compared under different amounts of test misalignments along the axial ($v_{\text{test,ax}}$) or lateral ($v_{\text{test,\text{lat}}}$) directions.
Figure S8. Color image projection results of a 5-layer diffractive PSR display (k=2) using a phase-only SLM and sequential illumination. a) Diffractive image projection results for different colored images from the Quick Draw test dataset. b) Diffractive image projections of colored line-pairs with a linewidth of \(1.066 \lambda_B\) are demonstrated for a PSR factor of \(k = 2\). For comparison, low resolution versions of the same test images using the same number of pixels as the corresponding input wavefront modulator are also shown in (a, right) and (b, left).
Figure S9. Comparison of the diffractive PSR image display with different hologram computation methods that use free-space propagation. Results of the 5-layer PSR diffractive display (k=4) are compared against different hologram computation methods including a CNN-based reconstruction (2nd row), iterative phase hologram generation (3rd row), and complex-valued hologram computation (4th row).
Figure S10. Image generation for the EMNIST display dataset. Different number of EMNIST handwritten letters were randomly selected and augmented by a set of predefined operations including scaling ($K \sim U(0.84, 1)$), rotation ($\Theta \sim U(-5^\circ, 5^\circ)$), and translation ($D_x, D_y \sim U(-1.06\lambda, 1.06\lambda)$) as detailed in the Methods section of the main text. These randomly selected and augmented handwritten letters were placed at randomly chosen locations in a $3 \times 3$ grid for each image in the EMNIST display dataset.
Figure S11. Optimization of the axial distance between the diffractive layers of the 5-layer PSR image display ($k = 4$) using a phase-only SLM. Average PSNR values for EMNIST display test dataset were used to optimize the layer-to-layer distance $d_2$ for the 5-layer PSR image display. Also see the Methods section of the main text.
Figure S12. Phase profiles of the trained diffractive decoder layers using a phase-only SLM at the input of each decoder. Each diffractive layer has a size of $106.66\lambda \times 106.66\lambda$, with a diffractive neuron size of $0.533\lambda \times 0.533\lambda$. 
Supplementary Table

Table S1. Axial distances for different diffractive decoder designs including 1, 3, and 5 diffractive layers used in our numerical and experimental results

|                  | $d_1$     | $d_2$     | $d_3$     |
|------------------|-----------|-----------|-----------|
| **Numerical**    |           |           |           |
| results          | 1 layer   | 6.667\lambda | -        | 173.333\lambda |
|                  | 3 layers  | 4\lambda   | 53.334\lambda | 53.334\lambda |
|                  | 5 layers  | 2.667\lambda | 66.667\lambda | 80\lambda     |
| **Experimental** |           |           |           |
| results          | 1 layer   | 26.667\lambda | -        | 173.333\lambda |
|                  | 3 layers  | 26.667\lambda | 53.334\lambda | 53.334\lambda |