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Acoustic lens: A thin plate with quasi-periodic array of holes

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ABSTRACT

A thin steel plate with quasi-periodic array of holes is fabricated, which is demonstrated to be able to function as an acoustic lens. With either a plane wave or a point source in object space, hotspots with the smallest size up to one-fifth wavelength are observed in the post-evanescent field regime in image space. Imaging of a point source with good resolution at different positions is also exhibited. The singular field distributions originate from the interference of the diffractive beams specific to quasi-periodic structures, which generates distinct and plentiful diffractive patterns.

1. Introduction

Metal plates drilled with nanoholes have exhibited many attractive optical properties, of which the most notable one is the extraordinary optical transmission through periodic and quasi-periodic nanohole arrays [1–3]. Recently, some other fantastic properties of quasi-periodic nanohole arrays which are absent for periodic ones have been noticed by Huang et al. [4–6]. In their works, metal screens with quasi-periodic pattern of nanoholes have been shown to generate subwavelength hotspots in the post-evanescent field and achieve imaging similar to conventional lens. The authors related the formation of subwavelength spots to super-oscillation, which means that band-limited functions can oscillate locally faster than their fastest Fourier components. Meanwhile, metal screens with other optimized patterns were also designed to realize subwavelength focusing and imaging of light beyond the evanescent region [7–10].

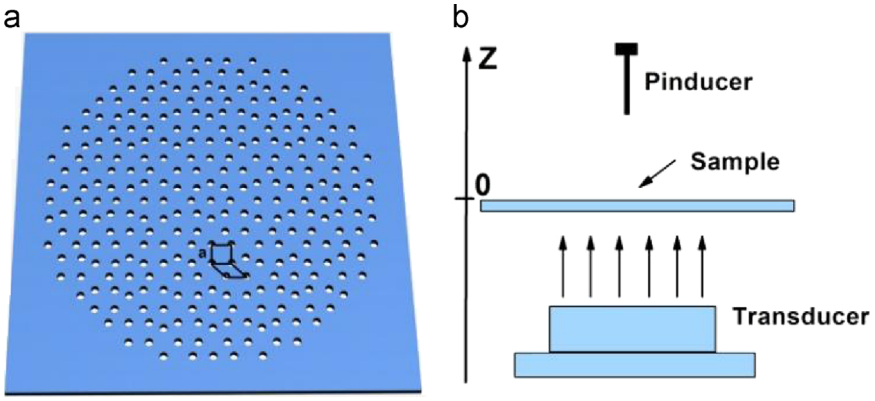

Fig. 1. (Color online) (a) Illustration of the sample made of a steel plate perforated with an eightfold quasi-periodic array of circular holes and (b) schematic drawing of the experimental setup.

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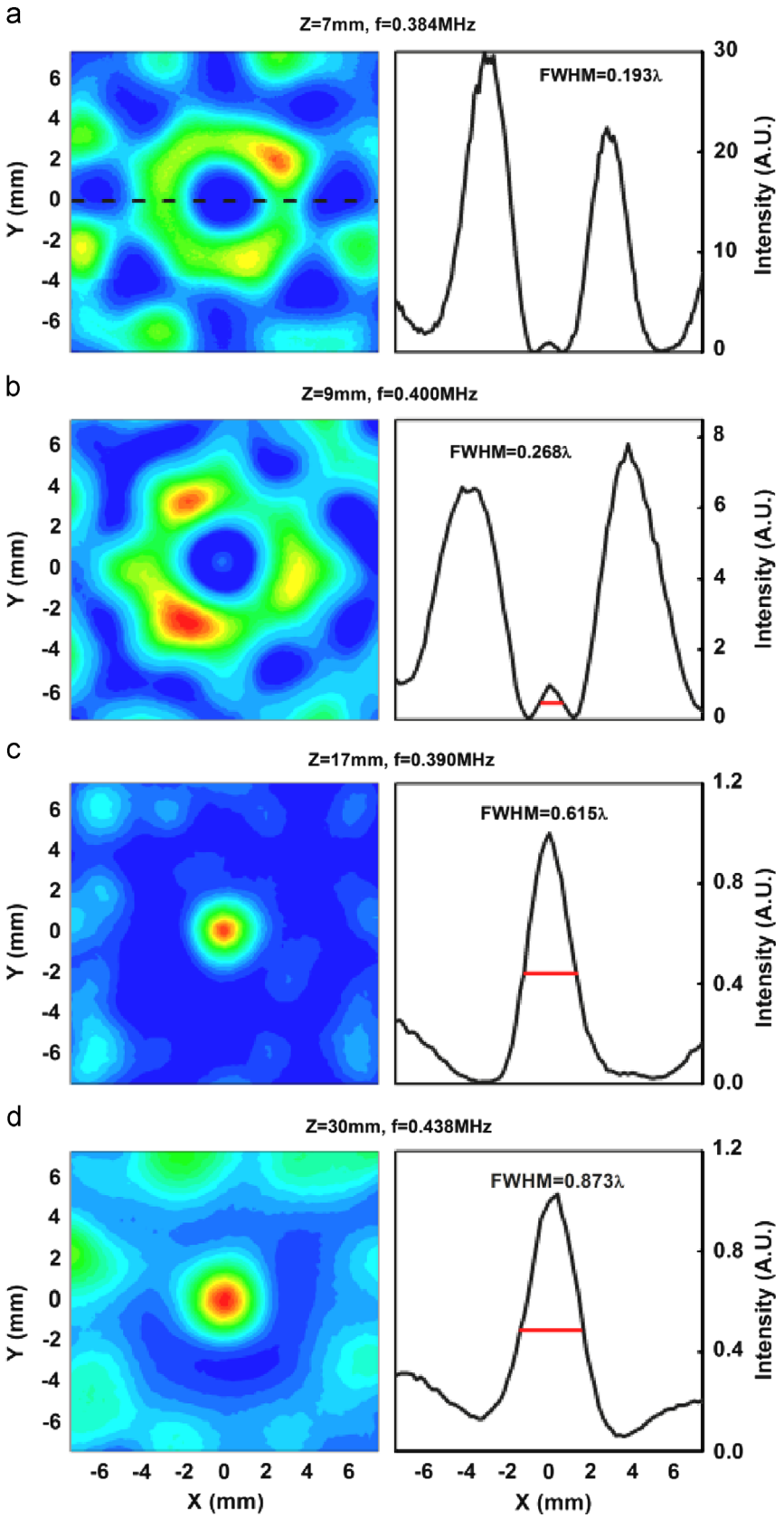

Fig. 2. (Color online) Left panel: the intensity distribution in *XY* plane at different height (along the *Z* direction) away from the surface of the sample for different frequencies with plane wave incidence, the area of each picture is 14.8×14.8 mm^2. Right panel: the intensity distribution of a cut line along the *X* direction at $Y=0$ mm (marked in (a) for example) in the left panel. The red lines mark the full width at half maximum (FWHM) of the spots.