Perturbed Frequency-Selective Surfaces Fabricated on Large Thin Polymer Membranes for Multiband Infrared Applications

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Frequency-selective surfaces (FSS) have received significant attention for their use as stop/pass-band filters at infrared frequencies[1]. At these frequencies, the dimensions of the elements of periodic arrays require micro/nano-scale patterning. In the last years, different lithography techniques have been reported[2-4] for the patterning of FSS. Usually, infrared FSS are designed on top of a dielectric layer which acts as a supporting substrate and is necessary to have appropriate strength, flexibility, transparency at infrared and resistance to fabrication processes/recipes. Polyimide has been shown to be strong enough and transparent at infrared[5], but it can be damaged readily in traditional fabrication techniques when used directly on sacrificial silicon wafers. Currently, increasing interest exists in extending FSS performance to multiband responses using single-screen FSS in order to reduce losses encountered in multilayered configurations. Recently, infrared elements based in fractal design have been reported[5]. However, the design of fractal FSS is a time consuming and non-intuitive procedure with fabrication restrictions. Moreover, fractal FSS lacks direct relationship between the shape of the elements and its spectral response in terms of key filtering parameters such as resonant frequency, absorption and quality factor. In contrast, simpler FSS consisting of perturbed elements have been shown to reach dual-band response in the microwave[6]. In addition, simply perturbed FSS have found applications in near-field enhancement[7].

In this work, we report on the design, fabrication and measurements of simply perturbed FSS fabricated on large free-standing thin polyimide membranes for applications in multiband infrared filters with up to four transmission/reflection bands. While the number of bands at resonance (rejected or transmitted) is found to be governed by the number of perturbations, the physical dimension (width, length and separation) of the strips/slots within the unit cell is shown to control the location and bandwidth of the resonances. The schematic of the process sequence is depicted in Fig.1. A 1μm layer of SiO_2 is grown thermally on both sides of a sacrificial silicon wafer. On the front side, the SiO_2 layer aims to protect the subsequently spun polyimide layer (1.7μm) from future dry silicon etching, while on the back it acts as the mask for future dry silicon etching. Aluminium have been sputtered on the polyimide, patterned photolithographically to form FSS based on parallel strips with length perturbations and dry etched, as shown in Fig.2. Finally, deep reactive-ion etching of sacrificial silicon wafer is carried out and the protective SiO_2 layer is wet etched by a solution of ammonium fluoride and acetic acid, which does not damage the thin polyimide membrane. The fabricated devices on large thin polyimide membranes are shown in Fig.3. The frequency response of the FSS has been simulated. Fig.4 shows the reflection coefficient of the multiband designs. FTIR measurements on the fabricated devices will be presented.

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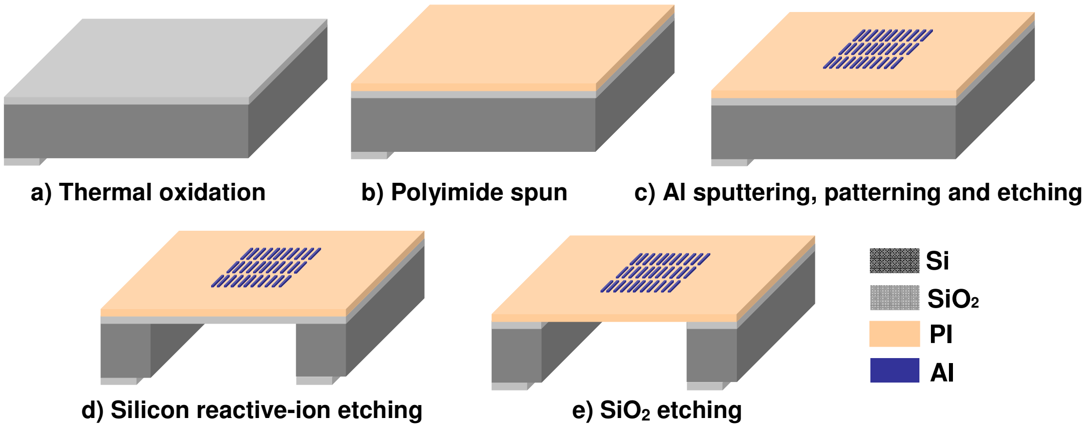

Fig.1 Schematic of the process sequence

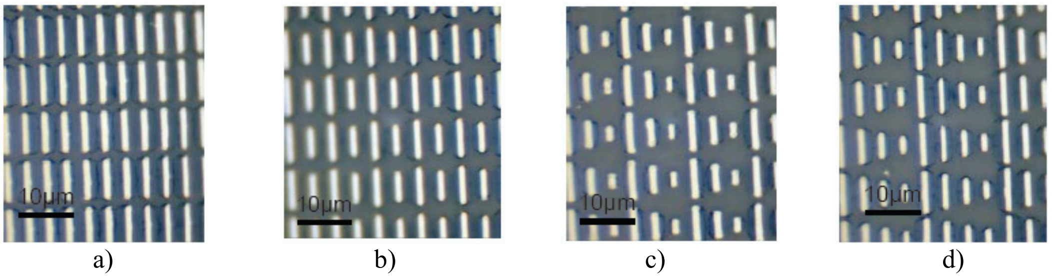

Fig.2 Optical microscope pictures of a) single-band, b) dual-band, c) tri-band and d) quad-band FSS

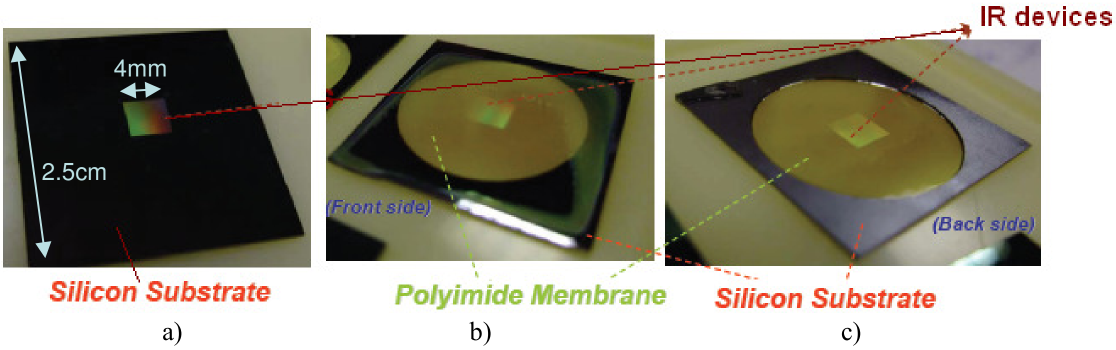

Fig.3 Fabricated infrared FSS on a) silicon wafer, b) polyimide membrane (front side) and c) polyimide membrane (back side).

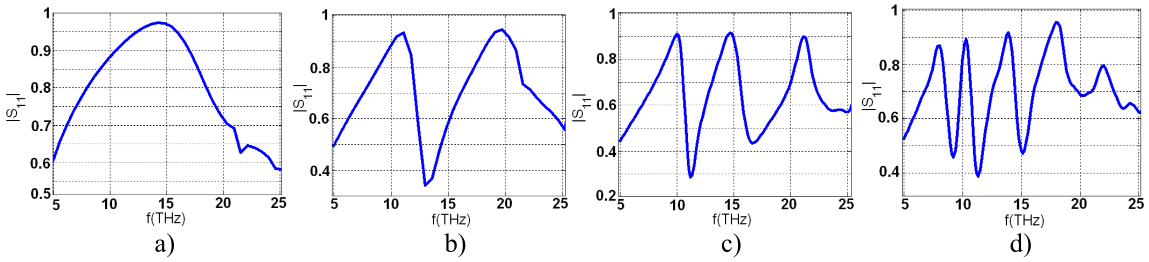

Fig.4 Reflection coefficient of a) single-band, b) dual-band, c) tri-band and d) quad-band FSS corresponding to the designs in Fig.2