ICP-RIE Etching of Sputtered Deposited SiO_2 Thin Films for Fabrication of Oxide-Cladding AlN Photonic Crystals

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A truly effective solution to overcome the communication bottleneck in short interconnections needs to address some requirements such as compatibility with CMOS manufacturing, low power consumption and high integration density. In recent works we have proposed and theoretically investigated solutions based on oxide-cladding aluminum nitride (AlN) photonic crystals (PhC). Currently, we are working in the fabrication of the proposed devices and so, we report the etching of SiO_2 thin films, that is one of the critical points in this process.

The PhC structure is formed by a triangular pattern of air holes perforated through a sputtered deposited multilayer of AlN and SiO_2. Details about the deposition process and the calculation of the PhC parameters in Figure 1(a) can be obtained in our previous work[1]. To investigate the etching process of the SiO_2 layers, a pattern of holes with varying diameters was transferred by electron-beam lithography to a spin-coated ZEP520 layer as showed in Fig 1(b). Then, the SiO_2 layer was etched with a mixture of C_4F_8/Ar in an Oxford Plasmalab-100 ICP-RIE etcher. We change the flux, chamber pressure and RF power in order to achieve a smooth sidewall profile and a reasonable etching rate. Both the parameters were accessed by cross-sectional images obtained in a dual FIB.

Figure 2(a) shows that the SiO_2 etching rate was greatly improved by a higher content of C_4F_8 in the gas mixture. This increases the chemical etching mechanism and also improves the selectivity to the ZEP520 (not showed). In contrast, lower pressures and higher RF powers increase the physical etching and improve both, the etching rate and slope as showed in Figure 2(b-c), however, at a higher level of mask degradation. The etching rate also increased with de hole radius, probably due to higher plasma densities. Therefore, a optimum etching process of the SiO_2 thin film is a result of a fine balance between the physical and chemical etching mechanisms. The best result was obtained for a 40%C_4F_8/ Ar gas flux, 6 mTorr chamber pressure and 25 W RF power (Figure 3).

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[1] E. G. Melo, D. O. Carvalho, A. S. Ferlauto, M. A. Alvarado, M. N. P. Carreño and M. I. Alayo, J. Appl. Phys. **119**, 023107 (2016)

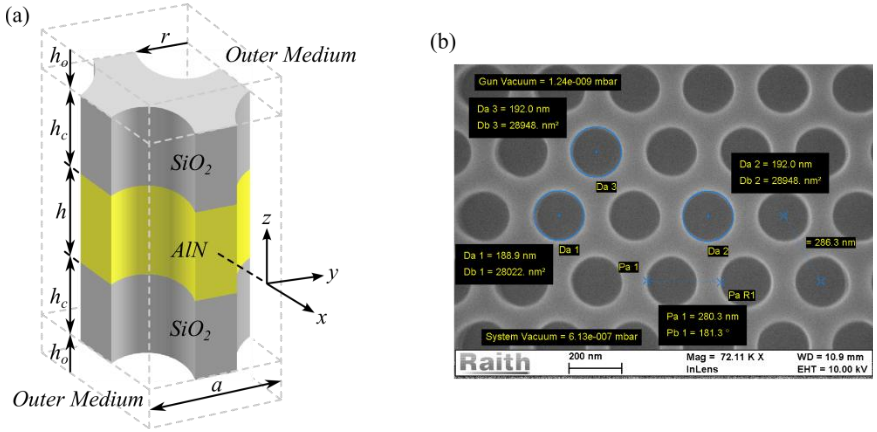

Figure 1: (a) Parameters of the PhC unitary cell. The PhC structure is formed by a triangular pattern or air holes perforated in a multilayer thin film with an AlN core surrounded by SiO_2 cladding layers. For a 633 nm wavelength a = 275 nm, r = 96 nm, h = 247 nm and h_C = 219 nm. (b) SEM image of the ZEP520 mask with a measured hole diameter of 192 nm. Measurements were also done in PhC with hole diameters of 136 and 490 nm.

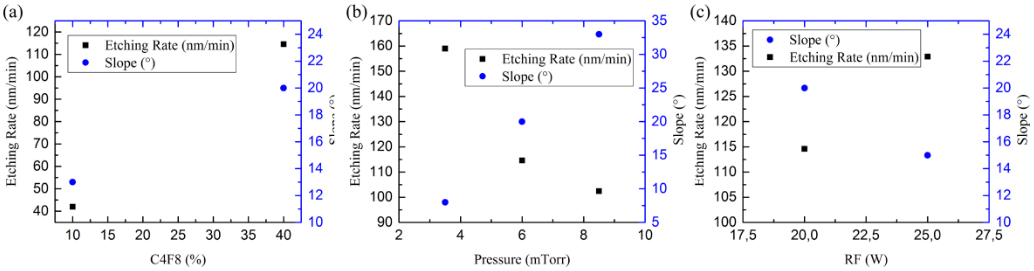

Figure 2: Etching rates and hole sidewall slopes for different contents of C_4F_8 (a), chamber pressure (b) and RF power (c). The coil power was set to 600 W and the total gas flux to 25 sccm.

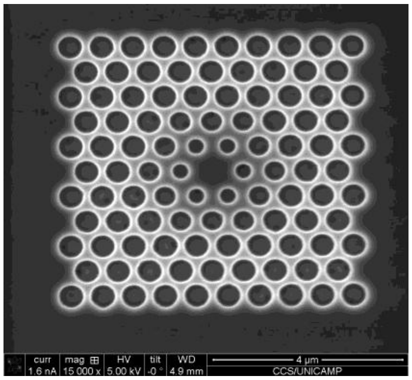

Figure 3: Result of an etching of the SiO_2 layer with C_4F_8/ 60%Ar gas flux, 6 mTorr chamber pressure , 25 W RF power.