Study of deposition parameters on the microstructure of magnetron sputtered amorphous silicon coatings with closed porosity

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Abstract

In last years, the research in porous silicon has become a growing field due to the many possible applications such as solar cells [1], optoelectronics [2] and photonic devices [3].

We recently presented a new bottom up method for the production of amorphous porous silicon coatings with closed porosity by magnetron sputtering [4]. The advantages of this approach in relation to the traditional electrochemical methods are the possibility to produce coatings with closed porosity by depositing directly on large areas and different kinds of substrates like glass or even sensible and flexible substrates like polymers [4], the close porosity avoids the aging drawbacks due to exposition to air, typical of open porosity obtained by electrochemical methods. In addition, the refractive index of the coatings can be easily changed just by changing the sputtering gas: coatings with closed porosity are obtained using helium as sputtering gas and denser coatings can be obtained with argon, which can be very interesting for the development of Bragg mirrors and optical cavities [4] by depositing multilayers of both materials. Our preliminary studies indicate that the closed pores are filled with the deposition gas [4, 5] (see also “Characterization of amorphous porous Silicon coatings by Transmission Electron Microscopy techniques”, R. Schierholz et al presented to this conference).

However, understanding the growth mechanism and the influence of the deposition parameters on the microstructure of these new porous silicon coatings is necessary. In this work we present a systematic study by electron microscopy of closed porous silicon coatings deposited by magnetron sputtering under different deposition conditions. The influence of vapor incidence angle (α=0º and 30º) on the pore alignment was investigated using the two setups, sketched in the figure 1(a and b); a clear orientation of the pores on the direction of vapor flux was observed [4](figure 1 c and d).

Oblique angle deposition (OAD) of porous silicon coatings was further explored in this work. The influence of pressure on the growth of columnar coatings has been widely investigated by other authors [6, 7]. A similar behavior was found for the pore orientation; increasing pressure results in a decreased angle for the pore alignment (see figure 1 e and f). The increased pressure results also in a narrower pore size as

observed in the insets of figure 1 e and f. Pore sizes can also be controlled by changing the power supplied to the magnetron (figure 1 g and h).

Other important parameters on the shadowing effects characteristic of OAD as substrate temperature [7, 8] and substrate bias [9, 10] were also investigated.

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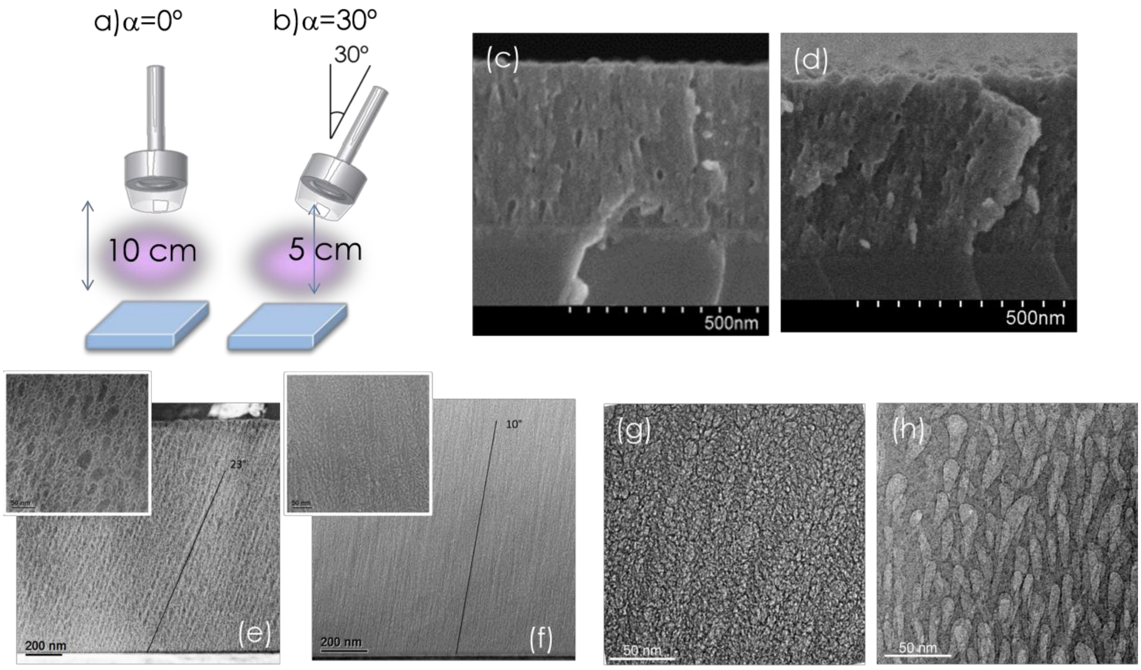

Figure 1 – Setups used for producing the coatings studied: (a) and (b); (c) deposition at α=0 (setup (a)); (d) deposition at α=30° (setup (b)); influence of pressure on pore orientation for α=30°: (e) 3.0×10^{-2} mbar and (f) $7.2\times10^{-2\ \text{mbar}}$. Influence of power supplied to the target on the pore size (deposition at α=30° and Helium pressure of 5.0×10^{-2} mbar): (g) 50 W and (h) 300 W.