Domain Formation in Semiconductors During Electrochemical Etching

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Anodic pore formation in semiconductors exhibits many features of self-organization, e.g. the formation of pore poly crystals in aluminum oxide [1], or pore single crystals [2] and self induced voltage and diameter oscillations in InP [3]. A subgroup of self organization is the formation of pore domains or patterns, i.e., laterally confined regions where pores show evident features of self organization around a central structure. Distinct domains were observed in Ge, GaAs, and GaP while in InP this feature is somewhat hidden. No domain formation has been observed in Si until the recent discovery of the rather exotic "fractal" pores [4] occurring in domains. Depending on the material, with prolonged etching time domains can start to overlap, fuse or create a cellular “catacomb" like structure [5, 6].

The domains in these materials can be quite different, e.g. the domains can have round shapes (Figure 1a, c) in one material and square shapes in another (Figure 1b), they may penetrate deeply into the semiconductor substrate or be confined to surface near regions. Nevertheless, it seems that all of them are triggered by a suppressed pore nucleation on the surface of the sample in conjunction with a self organization process leading to the formation of secondary, tertiary and so on which form the final domain

The pores constituting the domains are classified in two main categories: the so called crystallographically [7, 8] and the current line oriented (Curro) pores [9].

Crystallographically oriented pores grow along definite crystallographic directions and expose strong crystallographic features. Curro pores, on the other hand, do not expose any significant crystallographic features.

Domains containing crystallographically oriented pores have been observed in GaAs and Ge, whereas in GaP and InP domains of current line oriented pores are dominant.

This paper discusses in detail the formation conditions and domain morphologies and compares different type of domains in Si, Ge, and III-V compounds.

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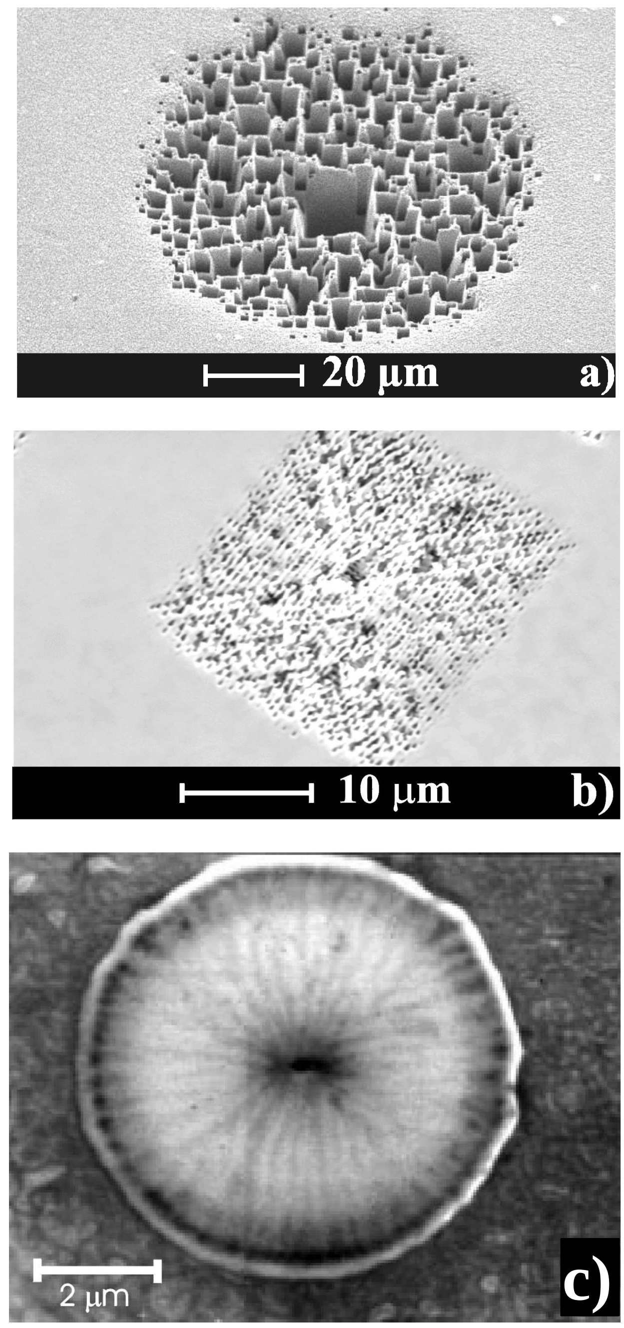

Figure 1. Porous domains in a) (100), n–type, Ge, $n = 10^{15}$ cm^{-3}; j = 2.5 mA/cm^2, 5%HCl, t = 120 min; b) (100), n–type, GaAs, $n = 10^{18}$ cm^{-3}; j = 50 mA/cm^2, 5%HCl, t = 30 min; c) (100) n-type, GaP, $n = 10^{17}$ cm^{-3}; U = 10 V, 5% H_2SO_4, t = 10 min.