Fabrication of Silicon Waveguides using Metal-Assisted Chemical Imprinting

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Scalable manufacturing of silicon (Si) waveguides is important for the development of the integrated optoelectronic systems. Nowadays Si waveguides are fabricated with photolithography methods[1,2] followed by reactive ion etching[3]. These methods, however, affect the manufacturing scalability and introduce sidewall roughness[3], which reduces waveguide's performance. Recently developed Metal-Assisted Chemical Imprinting[4] (Mac-Imprint) has the potential to overcome these limitations. Mac-Imprint combines contact-based nature of nanoimprint lithography[5] and catalyst-induced Si dissolution of metal-assisted chemical etching[6]. In particular, stamps, coated with thin film of gold (Au) are pressed against Si substrate by external forces in the presence of etching solution. The dissolution of Si is catalyzed at the points of microscopic contact between Au and Si and, thus, the inverse morphology of the stamp is transferred onto Si. Mass-transport of the reactants throughout microscopic Au/Si contact interface is crucial to assure pattern transfer fidelity[7]. To promote the mass-transport during Mac-Imprint of Si waveguides this work utilized stamps covered with nanoporous Au (np-Au), which was made by short-time scale dealloying of Au-Ag alloy. This approach drastically improved pattern transfer fidelity in comparison to the solid Au-covered stamps, however the imprinted Si surface exhibited roughness, which was correlated to the pore size of the np-Au. The pore size of the np-Au was then reduced through the adjustments of dealloying regime in order to approach the resolution limit of Mac-Imprint. This allowed to suppress the catalyst-induced roughness down to 10 nm, thus validating the applicability of Mac-Imprint for fabrication of Si waveguides.

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