Fabrication of Photonic Devices on Flexible Platform

Li Fan, Leo Tom Varghese, Yi Xuan, Ben Niu, Jian Wang, Minghao Qi*
School of Electrical and Computer Engineering, and Birck Nanotechnology Center, Purdue University, West Lafayette, IN 47906
mqi@purdue.edu

Organic polymers are the main components of flexible devices due to their ability to deform under stress.[1] Recently, inorganic semiconductor materials are used to realize flexible photonic devices by transferring patterned devices from a primary substrate.[2] Here, we propose and experimentally demonstrate a process of realizing photonic devices on transparent/flexible systems directly without the aid of transferring. It allows the integration of complex structures on such platforms directly.

By using high temperature plastic films, we deposited a layer of hydrogenated amorphous silicon by plasma enhanced chemical vapor deposition (PECVD) at a temperature of 200 °C. The photonic structures are realized on the plastic film using electron-beam lithography to pattern hydrogensilsesquioxane (HSQ) resist, followed by reactive ion etching in Cl_2/Ar chemistry to transfer the pattern into silicon. During processing, the plastic film is fixed on a flat silicon wafer to maintain its mechanical rigidity and ease of handling.

A number of waveguides, vertical grating couplers (VGC) and microring resonators are fabricated and optically characterized. Figure 1 (a-c) shows the fabricated devices on the plastic film. Figure 1 (d) shows the optical spectra of the devices. The microring resonators, with a 5 μm radius, have a free spectrum range of ~16 nm. The quality factor (Q) of the ring is ~3,200. The low Q is due to the roughness of the plastic surface and the material absorption of the amorphous system. Material absorption can be mitigated by optimizing the PECVD deposition process. The realization of photonic structures with inorganic materials on plastic films allows the integration of optical non-linear processes[3] on systems which require transparency and flexibility (Figure 2). By directly patterning the structures on the plastic film, it is possible to design multitude of circuits with increasing complexity and functionalities.

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[1] G. T. Paloczi, Y. Huang, and A. Yariv, Electronics Letters 39, 1650 (2003).

[2] J. A. Rogers, M. G. Lagally, and R. G. Nuzzo, Nature 477, 45 (2011).

[3] L. Fan et al., Science (2011).

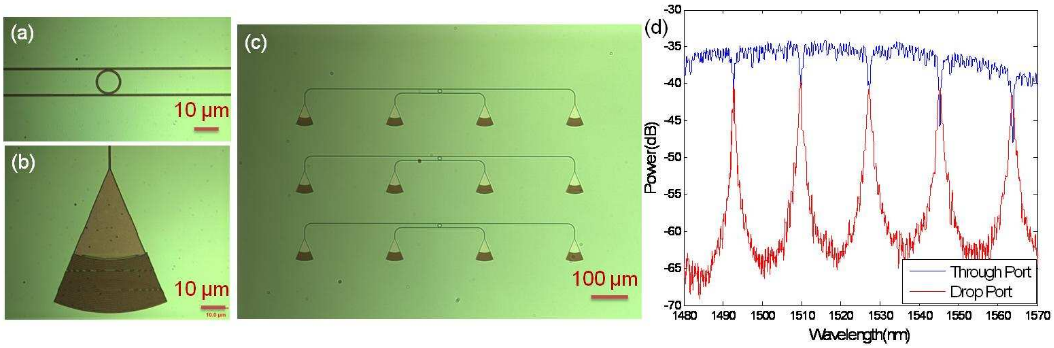

Figure 1: Optical microscope images and optical characterization of fabricated devices: (a) Microring resonator with in an add/drop configuration with gaps of 200 nm; (b) Vertical grating couplers with gratings of 720 nm period, etched all the way through; (c) The ring resonators connected to 4 VGCs spaced 250 µm apart; (d) The optical characterization of the device. Blue spectra denotes the through port transmission of the ring resonator with the red spectra showing the drop port response.

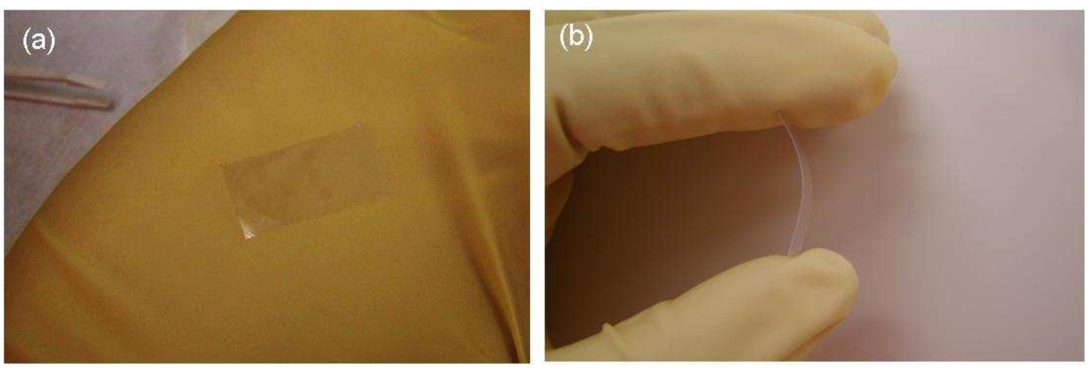

Figure 2: Macroscopic optical images of the plastic film with the optical devices patterned on it: (a) The plastic film is transparent with the photonic devices barely visible in the center; (b) The plastic film is flexible as shown in the picture.