Rare-earth-ion-doped Lasers Integrated on a Silicon Chip

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Future integrated photonic circuits will utilize hybrid integration of optical materials with different functionalities, among them optical gain. We have developed two rare-earth-ion-activated materials which can be directly deposited on any passive material platform, among others on silicon wafers. In a Nd-complex-doped fluorinated polymer, we demonstrated the first-ever continuous-wave solid polymer laser, operating at 1062 nm and 878 nm. In amorphous Al_2O_3, we demonstrated an Er-doped, widely wavelength-selective microring laser that operates across the telecom C-band. Employing Bragg gratings lithographically inscribed into channel waveguides, we obtained cavities with a *Q*-factor of $>10^6$. With such grating reflectors, we achieved a free-running 1542-nm distributed-feedback laser with an ultra-narrow linewidth of 1.7 kHz, equaling a coherence length of 55 km and a *Q*-factor of 1.14×10^{11}. With a distributed-Bragg-grating cavity, we obtained an Yb-doped laser at 1021 nm with 47 mW output power and 67% slope efficiency, which may enable linewidths below 100 Hz.