Reconfigurable Optical Signal Amplifier in Silicon Photonic Circuits

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This paper reports a cavity optomechanical signal amplifier driven by optical force in photonic circuit platform, with an amplification factor as high as 4. High amplification resolution is obtained through the precise optical force control. Different with conventional optical amplifier [1], the proposed design realizes the optical amplification using an optical force actuated nano-structure. The signal amplifier consists of a tunable ring resonator, an actuation ring resonator and a mechanical beam. Utilizing the nano-structure deformation by the optical force [2], a small input optical signal is amplified to a large output signal. An amplification factor as high as 4 is obtained experimentally and the modulating frequency is up to 4.2 MHz.

The modulated control light generate optical force in the actuation ring and drive the nano actuator whose motion changes the coupling coefficient between the input waveguide and the moveable waveguide. The net gain in driving the actuator results in the gain in modulating the input light. The optomechanical signal amplifier is analogous to the electronic transistor. It can be seen that the small input light will be amplified, resulting the large output light. The optomechanical amplifier is first biased at a certain optical power bias, shown as the working region in the picture. At the working region, a small AC signal of amplitude ΔPin is superimposed on the control waveguide, causing the output signal of amplitude of ΔP_{out}. The nano actuator can be precisely controlled by the optical force and the force is strongly depended on the position. Tuning the input power of the light will result in different deformation. The fabricated device is compatible with a CMOS-compatible process. The device is fabricated on SOI wafer using standard etching process. The optical characterization of the nano actuator is demonstrated in the experiment. The deformation of the structure shows an abrupt jump in a certain power, which result in a net gain in power control. When the moveable waveguide changes the gap between the fixed waveguide, the transmission changes.

In this work, a novel optical signal amplifier using a cavity optomechanical device is demonstrated. The signal amplifier is fabricated on silicon-on-insulator wafer using standard dry etching process. An amplification factor as much as 4 is achieved. Taking advantage of this method, we can use an optical light to control another desired optical light. In this way, the aim of controlling light with light can be achieved. The modulation frequency can be tuned and in our experiment, the 4.2 MHz is observed. Furthermore, we can improve the mechanical frequency up to gigahertz range, which may have potential use in radio-frequency photonics applications.

[1] Francis, *Optical Fiber Communication Conference*. Optical Society of America, 2001.

[2] Ren, Min, et al. *ACS nano* 7.2 (2013): 1676-1681