Silica Nanowire Devices

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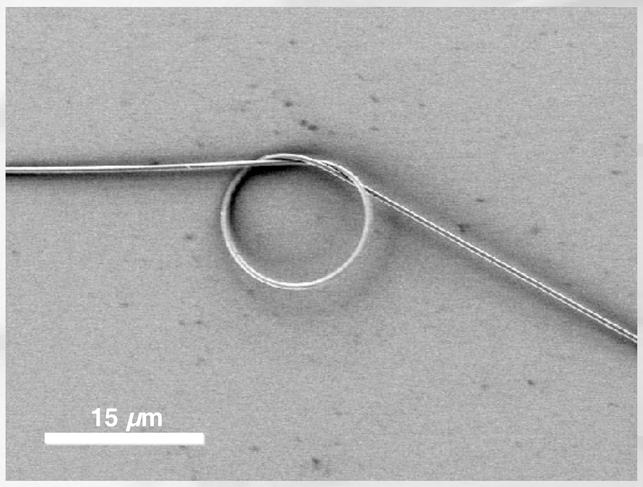
Research Goals

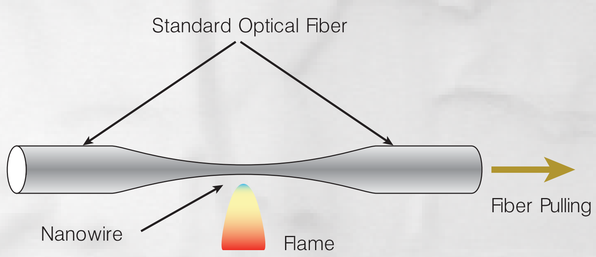
As information technology becomes more dependent on optoelectronic devices, there is an increasing need for denser integration of processors and optical components that have fast response. In order to achieve fast integrated devices, we need to overcome the challenges associated with miniaturization and integration.

One approach to building nanophotonic devices is to use silica nanowires. Silica nanowires are inexpensive, easy to couple into using standard fiber– launching techniques, and can access nano–sized dimensions. They can be optimized for signal routing, sensing or for nonlinear optics. The flexibility and strength of nanowires enables reconfigurable devices, making them an attractive platform for prototyping.

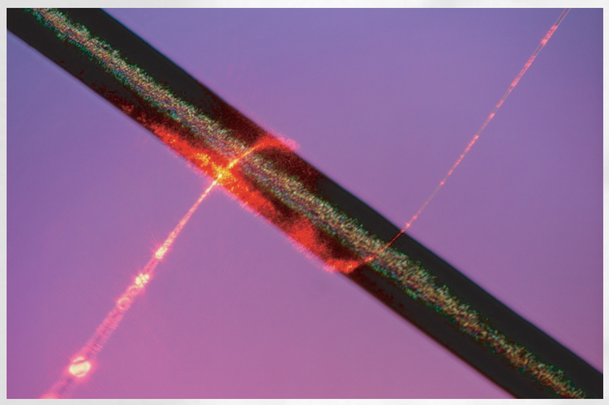


Silica Nanowires

Silica nanowires are formed using a flame-drawing technique with standard optical fiber and can produce nano-sized waveguides with good uniformity. The smallest of these waveguides guides light almost entirely in the evanescent field. When used in conjunction with their macroscopic ends, light can be efficiently coupled into and out of micro and nano-photonic structures.



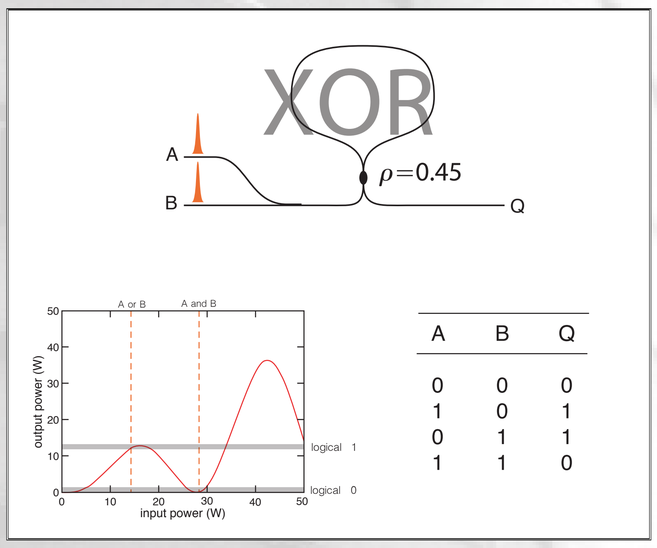
Slightly larger nanowires exhibit a high degree of confinement. This produces a large effective nonlinearity for our waveguides, over 20 times greater than standard optical fiber. This enhanced effective nonlinearity is the driving mechanism for our silica based nonlinear nano-photonic devices. On the left we see light in a nanowire which is wrapped around a hair.



Approach

We fabricate nonlinear Sagnac interferometers using silica fibers. We are working toward optimizing such structures to perform all–optical switching on lengths scales significantly smaller than those on which switching has been previously achieved. The geometry of the Sagnac interferometer can be formed using a 2x2 coupler in a single nanowire as shown below. The effective path difference results from the optical Kerr effect, which is substantially enhanced by the nanoscale dimensions of our optical fibers.

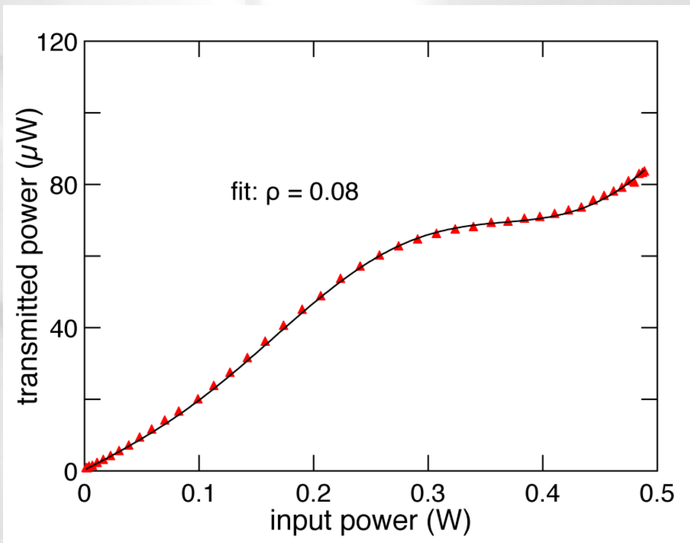
If the coupler is not exactly 50:50, a different phase will be introduced between the clockwise and counterclockwise propagating pulses, producing intensity dependent interference fringes that can be used to perform logic operations. Information encoded using a pulse intensity scheme can be processed using such optical switches if output "bits" correspond to specific fringe locations.



A	B	Q
0	0	0
1	0	1
0	1	1
1	1	0

Results and Outlook

We have fabricated a nonlinear Sagnac interferometer using the silica nanowire platform. Through measurement of the transmitted power as a function of input power, we observe a distinct nonlinear response that is indicative of light–by–light modulation. Our data displays excellent agreement with the theoretical prediction if the coupling parameter is very small (0.08). Our preliminary results demonstrate that all-optical modulation is achievable in a silica nanowire. This serves as a proof of principle investigation for nano-photonic devices in both the silica nanowire platform and future material platforms.



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http://mazur-www.harvard.edu