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NONLINEARITY OF LIQUEFYING GALLIUM: A BREAKTHROUGH OPPORTUNITY FOR CONTROLLING LIGHT WITH LIGHT AT MILLIWATT POWER LEVELS

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We have found that an interface between glass and metallic gallium held just below the melting point shows an astonishingly large broadband cubic nonlinearity reaching {chi}(3) ~ 1esu . his constitutes a new type of nonlinear optical response. This large nonlinearity is available in a very versatile material geometry, it works at room temperature and has major device potential in optoelectronics. The physical mechanism behind the nonlinearity is related to a new type of optically induced phase transition between two phases of gallium and shows critical behavior of the material susceptibilities and relaxation times appropriate to a second-order phase transition. The nonlinearity is much faster than in liquid crystals and has the advantage of being very broadband in comparison with the near band-gap and exitonic nonlinearities in semiconductors. It spans from visible to near infrared covering important telecom spectral windows. The nonlinearity is fully reversible and the effect is stable as long as the sample temperature is maintained to within 1°C just below the melting point of gallium which is about 29°C We have demonstrated that the nonlinearity is fully compatible with waveguide technology as the gallium mirror may be formed at the tip of a single mode fiber. A high-contrast optical switch has already been demonstrated operating at milliwatt light power levels, with a roll-off frequency in excess of 100kHz. The switch is also capable of routing sub-microsecond optical pulses. In another application, a liquefying gallium mirror was used to achieve q-switching of an erbium fiber laser.

1. N.I.Zheludev, D.Richardson, S.Dhanjal. UK Patent application # 9724150.9 of 14th of November 1997.
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3. P. Petropoulos, D.J. Richardson S. Dhanjal and N.I. Zheludev. Passive Q-switching of an Erbium Fibre Laser Using Nonlinear Reflection from a Liquefying Gallium Mirror. CLEO?98 San Francisco, CA, USA, May 1998. Peper CTuE5.