# LANTHANIDE-DOPED PHOTONIC CIRCUITS

James S Wilkinson

Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, Hampshire, SO17 1BJ, UK

Silicon photonic circuits exploit microelectronic processing technology to enable a revolution in mass-manufacture of photonic systems, building on the earlier revolution in electronic systems which enabled complex electronic functionality at low cost. To provide full photonic functionality, in terms of amplification, switching, filtering, all-optical processing, delay and storage, new fabrication processes and new CMOS compatible complementary materials systems must be developed. Silicon dioxide is ideal for many photonic applications but its small nonlinearity, low refractive index, poor lanthanide solubility and limited IR transmission precludes its application to high-density all-optical circuits or new wavelength windows. Silicon itself has exhibited remarkable performance for compact linear and nonlinear optical devices and while waveguiding in silicon is attractive at wavelengths beyond 1.1μm, the use of Si3N4 for optical parametric oscillators [1] has emphasised that silicon does not meet every need. More recently, lanthanide-doped Al2O3 has been combined with Si3N4 waveguides on silicon as an alternative route to providing gain in Si/Si3N4 photonic circuits [2]. Tantalum pentoxide (Ta2O5) is an alternative CMOS-compatible waveguide material and several important properties and functions for high-density photonic circuits have been demonstrated. These include suitability as a host for rare-earth ions, with amplification and lasing demonstrated at 1.5μm [3] and 1.02μm [4] for example, and third-order nonlinearity at least 30 times that of silica [5,6]. Ta2O5 has a large bandgap (4-2 – 5.2 eV) so that, at a conservative estimate, two-photon absorption (TPA) is not evident for wavelengths longer than 700nm, while in the case of Si, TPA is significant at wavelengths below 2.25μm. The CMOS compatibility of these materials allows combination in a multilayer configuration with silicon photonics to offer complementary functionality within silicon photonic circuits. Ta2O5 exhibits good transmission at wavelengths between 350nm and 8μm, opening up the potential for mid-infrared devices. Progress in lanthanide-doped CMOS compatible photonic circuits will be reviewed and recent results discussed.

## References

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