Alberto Santamato, Dipartimento di Ingegneria dell’Informazione, Universit`a degli Studi di Padova, Padova, Italia

QKD silicon based Integrated photonics devices for space application

Secure communication at high rates and long distances is certainly an amenable and foreseeable technological implementation which can be achieved with the technology available nowadays, taking advantage of off the shelf components [1]. Leaning on well established results stemming from quantum mechanics, it is possible to securely share a secret key (string of bits) between possibly very distant parties. Fiber technology is already mature enough to support such beneficial scenario, nonetheless it suffers from the unavoidable, perhaps reducible, propagation losses experienced by light through optical fibers.Striking a good balance between rate and range of the communication is challenging. To mitigate this unwanted effect, earth-satellites communication channels are an appealing option, since they can accommodate for propagation losses at expenses of good coupling at the two ends. Integrated photonics on the other hand offers a huge advantage in terms of volume, weight, power requirements, stability and possibly price over the fiber solution to realize the transmitters [2].Those modules can be allocated in dedicated satellites or nano-satellites with minimum impact and great versatility.An open question on integrated photonics is the compatibility with the harsh space environment. A key issue is the strong presence of charged particles which can penetrate through the satellite and possibly deposit energy in silicon devices. Through a joint collaboration between Istituto Sant’Anna among Scuola Superiore Sant’Anna/TeCIP, CNIT/PNTLab and Quantum future group (supported by funding of the Italian Space Agency), photonic integrated devices have been developed and designed capable of implementing efficient BB84 protocol with decoy states both in polarization and time bin encoding; active components with bandwidth > 10 GHz have been integrated to boost the maximum raw rate of transmission. Alongside the QKD transmitter we designed an improved version of existing integrated QRNG [3],[4],[5], which will support the communication system. This was possible taking advantage of the Multi-Project Wafer service offered by IMEC for fabricating the integrated photonic chips. Padova group possesses long time expertise in Earth-to-satellite communication with single photons (thanks to the collaboration with MLRO in Matera), an essential feature to achieve the goal [6] whereas TeCIP and PNTLab contribute a strong expertise in advanced Photonic Integrated circuit design and fabrication [7].An FPGA based control system has been realized to optimize the visibility of the signals (extinction ratios) and to control the entire communication protocol, moving a first step to assess the expected capabilities in laboratory (controlled environment). Our main interest though is the compatibility of such technology with space missions (satellite) where the environment is not under control and intense fluxes of particle are omnipresent and unavoidable. A part from the refractive index changes and the possible increase of losses due to extra absorptive defects, a further detrimental factor due to cosmic radiation is the alteration of the charge composition of the active elements such phase modulators and photodiodes.We are investigating the tolerance of these devices against proton irradiation at different fluences and quantitatively estimating the expected effects in different orbits. Space evaluation of such technology is an essential first step for future developments.,

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