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Energy consumption levels in 300-Gb/s-class signal processors

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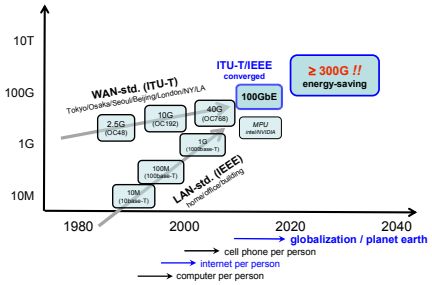
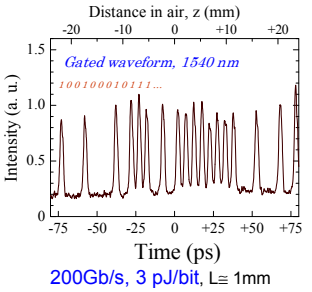
Target Application, for future ICT

- **serially**-faster, integer-signal-processor technology, as productive option to, many-core-MPU strategy.
- **speed 300 Gb/s**, energy 0.3 pJ/bit, size 250×250μm². electronic Intel 4004, 80386 → **All-Optical.**

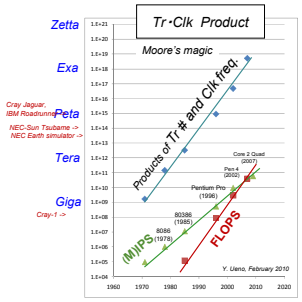


Backgrounds and recent understandings:

- proto-type-device demonstrations (160-to-640-Gb/s).
- latest energy-consumption: 3 pJ/bit (gates and memories). electron-number consumption: ≈1×10⁷ electrons/bit.
- optical-acceleration scheme will be equivalent to faster materials, such as QD, ISBT (AIST), and Be-doped (NTT) materials.



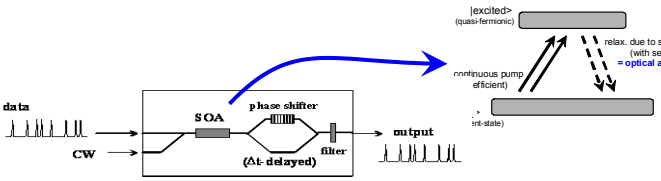
200Gb/s, 3 pJ/bit, L≅ 1mm
Sakaguchi et al. (**UEC Tokyo, 2009**)

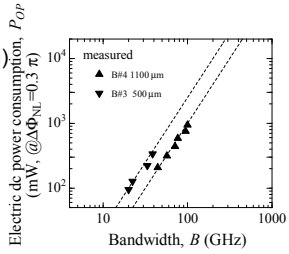


Sources: FLOPS from measured results, MIPS from wikipedia.

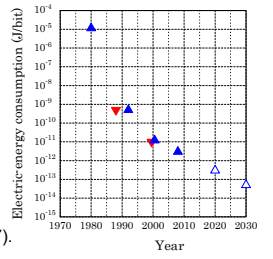
On-going research subjects, after recent understandings:

(1) to enhance efficiency (from electron modulation to refractive-index modulation).
(2) to revise signal-discrimination scheme (from non-degenerate to degenerate).
(3) to enhance density of excited electrons (from dilute to denser).





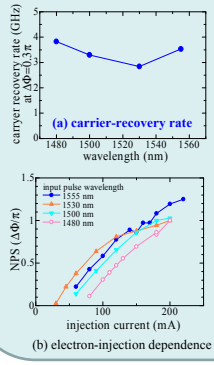
Scaling rule for energy consumption (UEC, 2007).



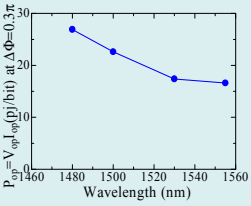
Energy consumptions for all-optical gates
▲ semiconductors, △ expected (▼ silica-fibers)

This series of works (F. Salleras, M. Honma, N.T. Anh, S. Sakano et al.):

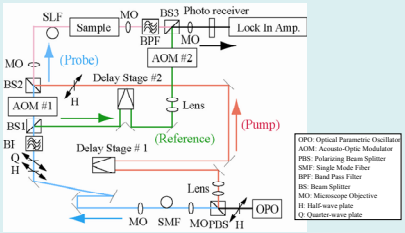
material-level characterization research (much more flexible than device-level characterization, e.g., dependences on signal-wavelength), primarily for characterizing dependences of refractive-index modulation-depth, and resultant device-level energy-consumption levels (pJ/bit).
Example of preliminary results (under study and discussion):



(b) electron-injection dependence



(c) Dependence of energy consumption, on the data-signal wavelength.



Experimental setup w/ 80-MHz Ti-sapphire mode-lock laser.

Rm 513, 5th floor, W7 bldg., UEC.

References:
1) S. Nakamura, Y. Ueno, and K. Tajima, IEEE Photon. Technol. Lett. **13** (2001) 1091, 2) Y. Liu, E. Tangdiongga, et al., J. Lightwave Technol. **24** (2006) 230, 3) Y. Liu, E. Tangdiongga, et al., J. Lightwave Technol. **25** (2007)103, 4) J. Sakaguchi, T. Nishida, and Y. Ueno, Opt. Comm. **282** (2009) 1728, 5) J. Sakaguchi, F. Salleras, K. Nishimura, and Y. Ueno, Optics Express **15** (2007) 14887, 6) Y. Ueno, Solid State Devices and Materials (ssdm2010), Sept. 2010, U. Tokyo, 7) Y. Ueno, 5th Triangle Symposium on Advanced Information and Communication Technology (TriSAI), October 2010, BUPT Beijing, 7) David Patterson, "The trouble with multi-core," IEEE Spectrum vol. 47, no. 7, pp. 24-29, July 2010.