Optical Device

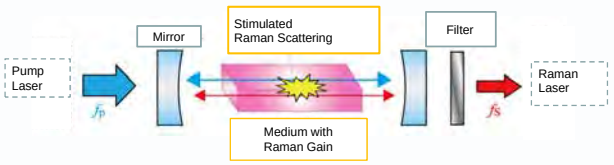
A micrometre-scale Raman Silicon Laser with a microwatt Threshold

Associate Prof. Yasushi TAKAHASHI(Osaka Prefecture University)

1. Silicon Raman Laser

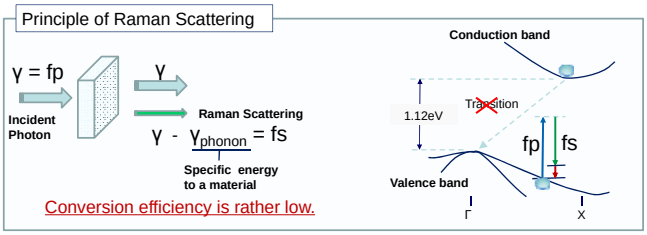
- Raman laser is the only silicon laser, but
- Currently proposed Si laser needs the improvement
  - miniaturization to micrometer dimensions
  - reduction of the threshold to microwatt powers

Stimulated Raman Scattering with cavity



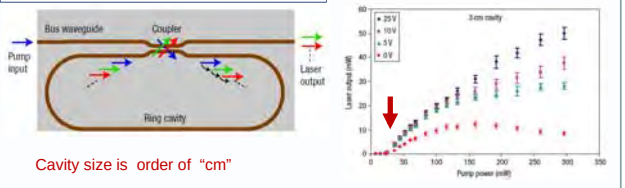
Large cavity size is necessary for high Raman Gain.

Principle of Raman Scattering



Conversion efficiency is rather low.

Example of silicon Raman laser



Cavity size is order of "cm"

H. Rong *et. al.*, Nature Photon. 1, 232 (2007). Threshold power is ~20mW

2. Principle of the Invention

- To utilize two types of nanocavity mode in hetero nanocavity
- To fabricate the cavity along the [100] crystal direction

- Photon is localized in a cavity with a volume, ~λ^3
- Q-value > 10×10^5 in Odd nanocavity mode
  10×10^6 in Even nanocavity mode
- Δ of frequencies is tunable by the air-hole radius

G[・]: Raman gain in each direction

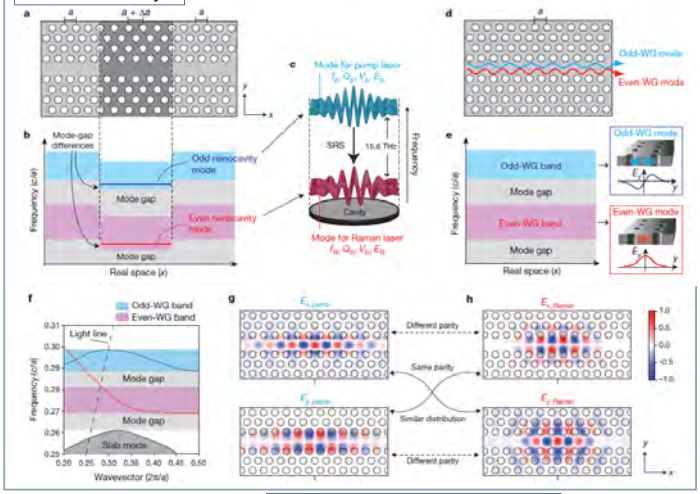
$$G_{[100]} \propto \iiint_{Si} \left| E^*_{x\_Raman} E_{y\_pump} + E^*_{y\_Raman} E_{x\_pump} \right|^2 dx\,dy\,dz$$

$$G_{[110]} \propto \iiint_{Si} \left| E^*_{x\_Raman} E_{x\_pump} - E^*_{y\_Raman} E_{y\_pump} \right|^2 dx\,dy\,dz$$

G[100] >> G[110] , then [100] is favorable

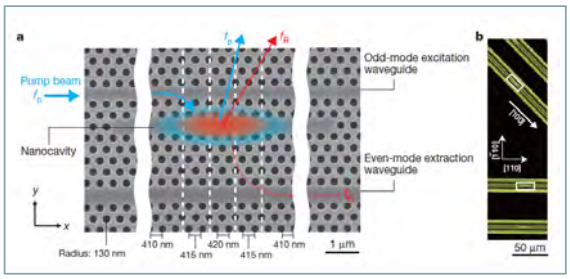
Hetero nanocavity

Y.Takahashi et.al., Nature vol.498 27 June 2013 p470-474



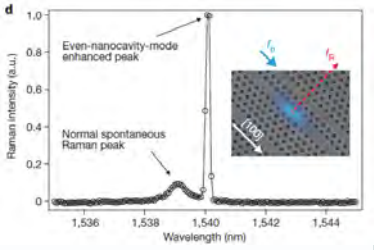
3. Characteristics

Both [100] & [110] devices are evaluated.

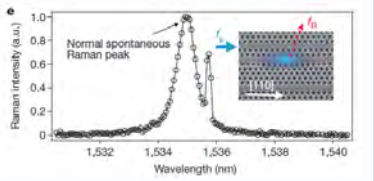


- Threshold power : 1uW, 20,000 times smaller.
- Chip size is 10,000 times smaller.

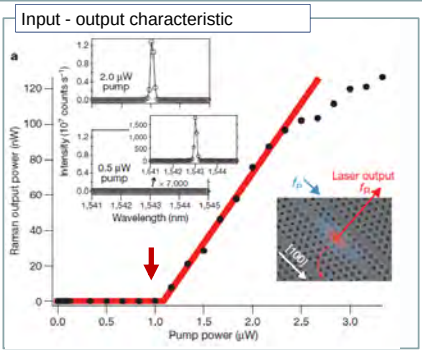
[100] device



[110] devices



Input - output characteristic

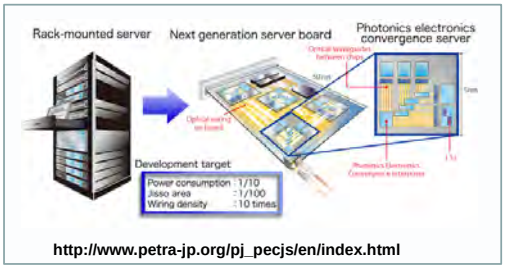


Chip size

4. Application Examples

- Realization of the convergence between photonics and electronics
- Various industrial applications

→ Laser with the current mode excitation is under development.



- Inter-chip connection (Interposer)
- O/E interface inside the chip

Patent Licensing Available

Patent No.: WO2014/030370

JST/ IP Management & Licensing Group Phone: +81-3-5214-8486, E-mail: license@jst.go.jp