STA 2.1 Materials and Devices for All-Optical Signal Processing

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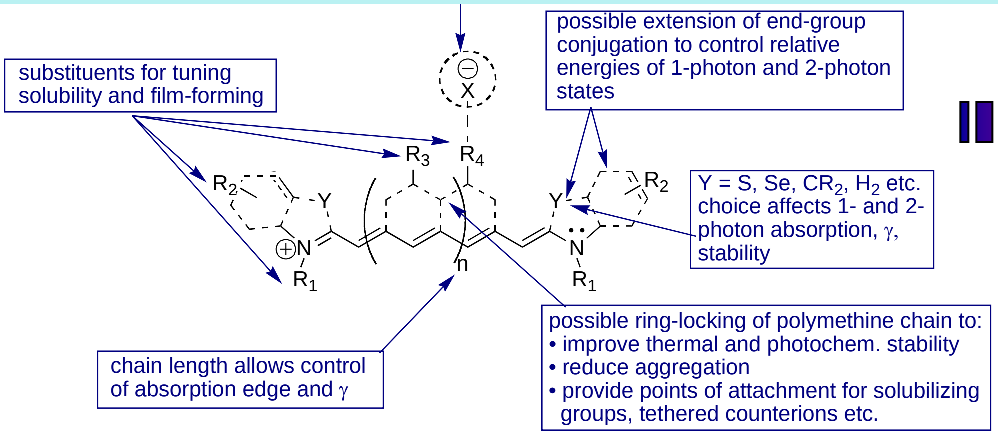
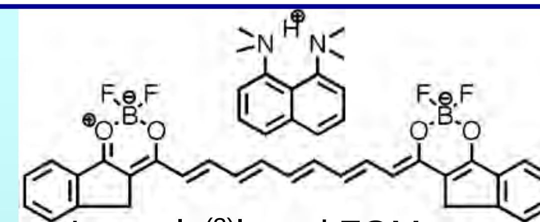
Organic Materials for All-Optical Devices

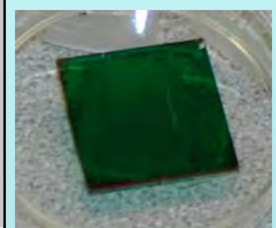


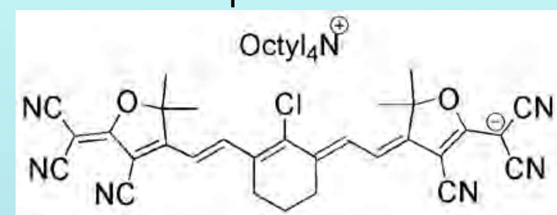
Molecular engineering for optical response and processability

Organic All-Optical NLO Materials



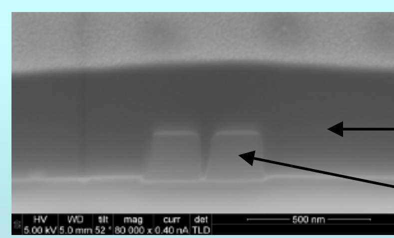
- Large $|\chi^{(3)}|$ and FOM
- Ultrafast response

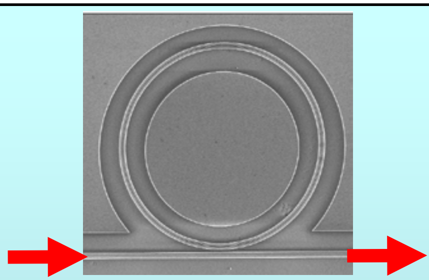


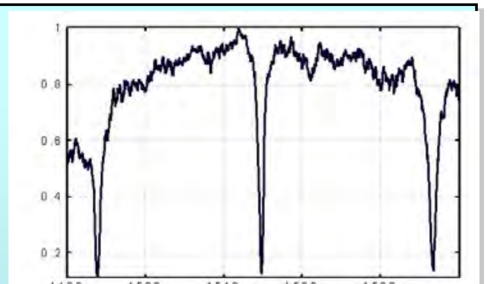


- Processable into good quality films for device integration
- Sizable $|\chi^{(3)}|$ (~6 x 10^{-11} esu)

Integration with Si Photonics

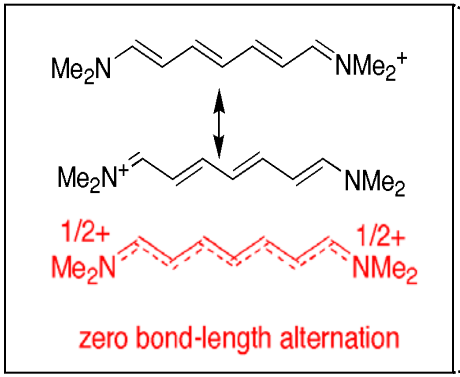


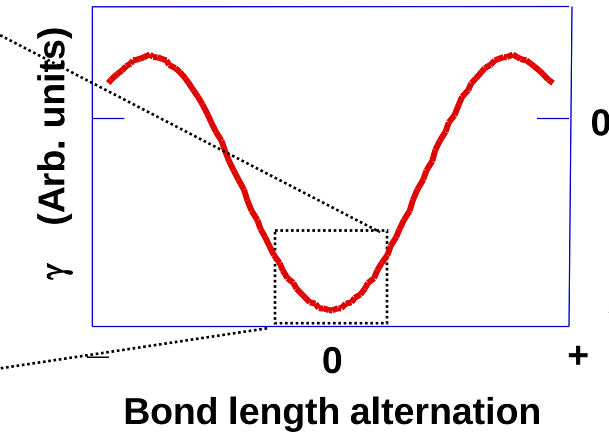




Optically Switchable Photonic Devices

Optimizing Chromophores for All-Optical Switching

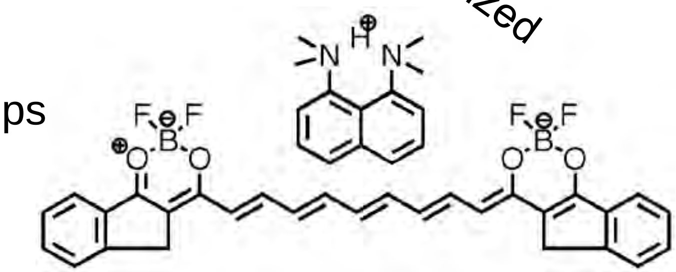




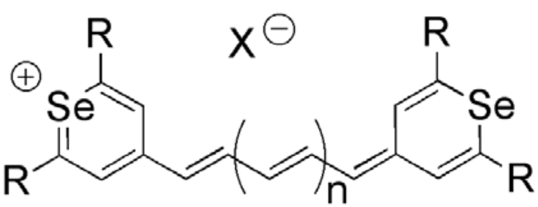
Marder, S. R. et al., *Science* **265**, 632 (1994)

- Cyanine-limit: max |γ|
- High order dependence on length: γ ~ N^7 or higher

Increased length, delocalized terminal groups



Optimizing terminal groups



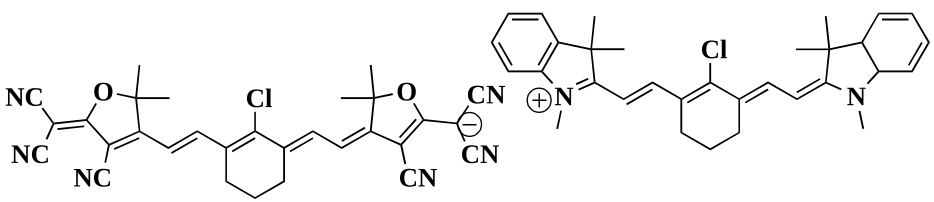
- Selenopyryllium cyanine with very large large γ
- FOM = Re γ/Im γ ~ 100 in telecom band!

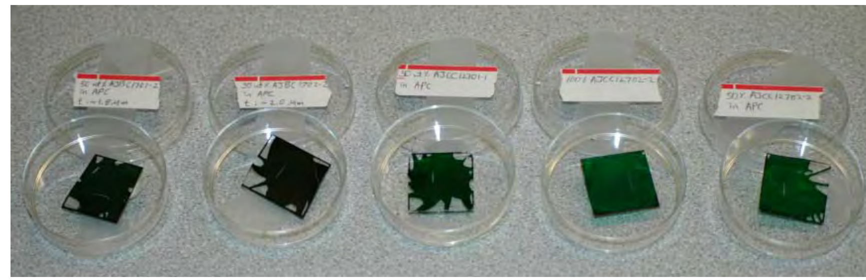
Hales et al., *Science* (2010) in press

- Extended DOB cyanine with large γ and $|\chi^{(3)}|$ (3.6×10^{-10} esu)
- FOM = Re $\chi^{(3)}$/Im $\chi^{(3)}$ = 10
- >200 GHz bandwidth

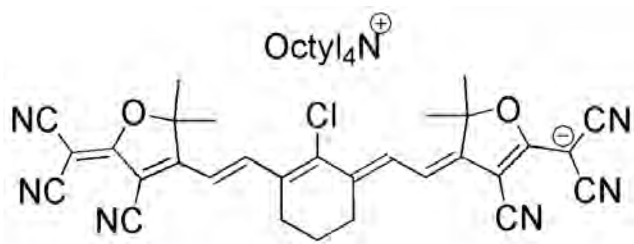
TCF Cyanines: Processable Materials

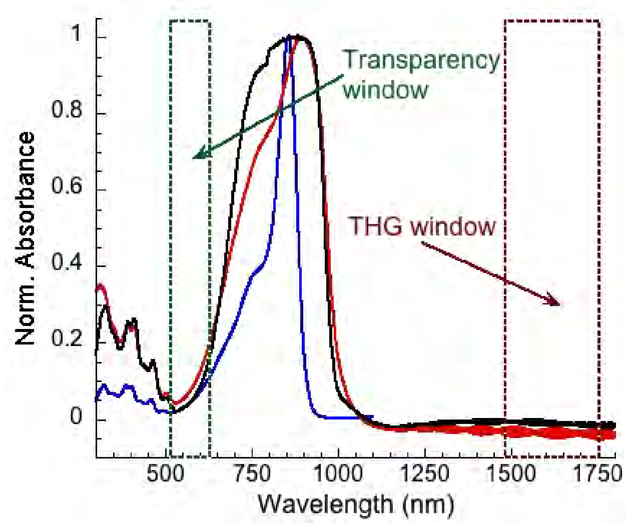
• Cyanines with complementary charges showed improved optical quality of resulting films





• TCF-terminated cyanines with TOA cations for good solubility, processability, and low NIR absorption.

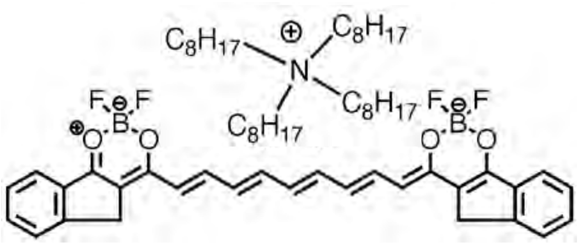




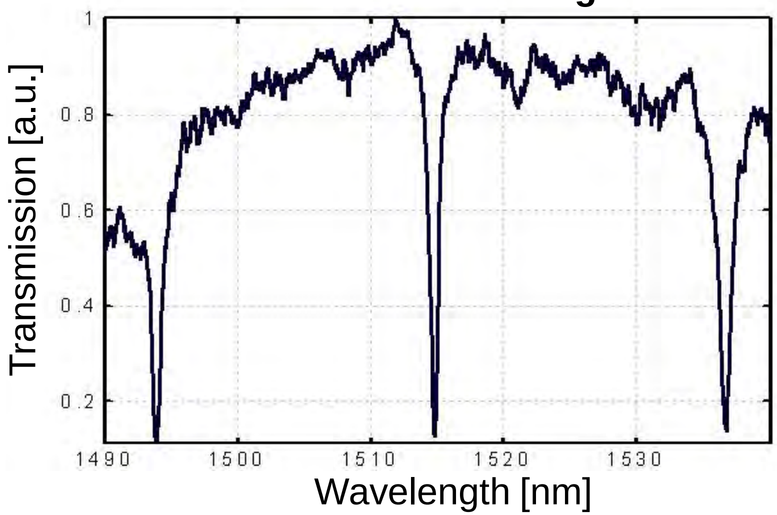
Jen, Marder, Perry Groups

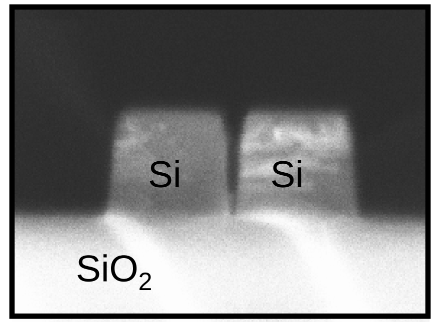
Device Applications of Cyanines: n_2

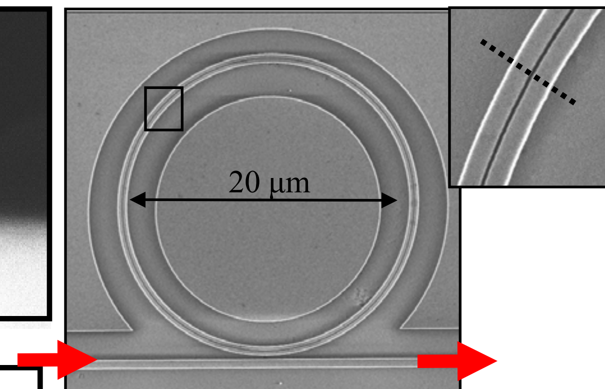
Keys: Large ratio of $Re(\chi^{(3)})/Im(\chi^{(3)})$
Low loss spin-coated films

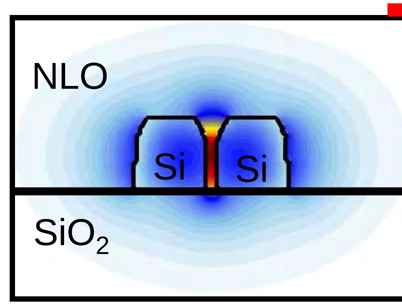


Measured resonances in coated slotted-ring









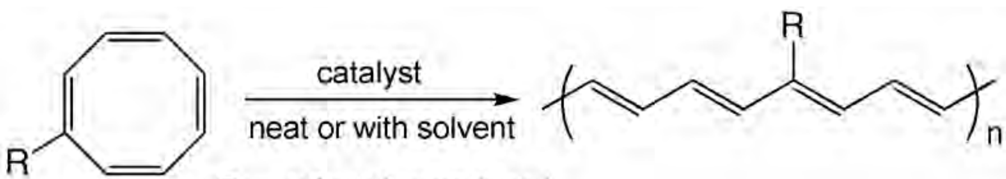
Simulated Mode Profile

- 0.6 THz intrinsic bandwidth for coated slotted ring
- ~100 mW pump power to achieve 3dB modulation
- 1000x size reduction in device size due to field enhancement in a slot resonator

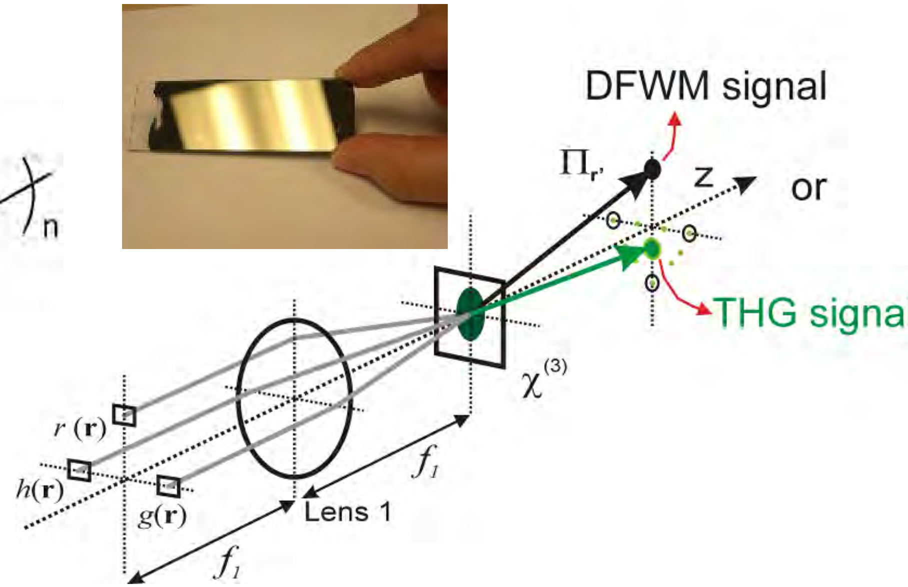
Perry, Marder, Lipson, Hochberg Groups

Processable Polyacetylene for All-Optical Image Processing

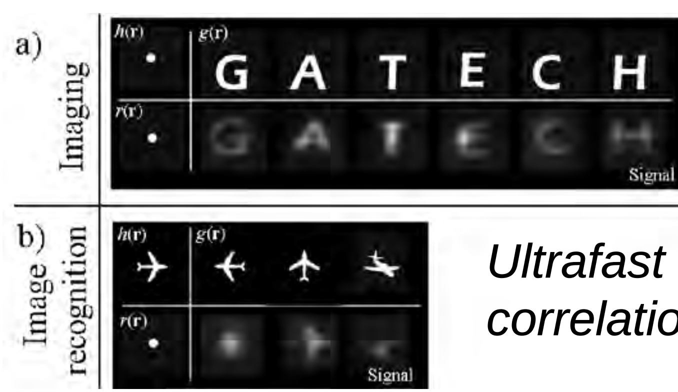
in-situ polymerization



R = *n*-butyl, *sec*-butyl



- Large $|\chi^{(3)}|$ (2.0×10^{-10} esu) for optimized polymerization conditions
- >10 THz temporal bandwidth
- Moderate NIR loss (~ 30 dB/cm)
- Processable into good optical quality thick or thin films



Ultrafast DFWM image correlation

S. Chi, et al., *Adv. Mat.* **20**, 3199 (2008)