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Title: Polarization dependence of ultrafast dynamics in single Si nanowires

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Polarization dependence of ultrafast dynamics in single Si nanowires
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-abstract-
Understanding how light interacts with individual nanowires (NWs), particularly depending on its polarization with respect to the according to itsNW alignment, and polarization status of incident light is essential for an optical characterization and furthera wide range of engineering applications. We report present the first ultrafast time-resolved, polarization-dependent experiments on polarization dependence of ultrafast dynamioncs in both single- and ensemble-silicon nanowires using non-degenerate pump-probe spectroscopy to excite and probe carriers above the indirect band gap. Polarization sensitive pump-probe excitation and detection reveals a clear anisotropy in the ultrafast time dynamics measured parallel and perpendicular to the long axis of a single nanowire with different probe absorption respectively. Meanwhile In addition, the magnitude of the photoinduced change in ensembles of nanowires NWs varies for four different sets of pump and probe polarization, without an anisotropy in relaxation time. The comparison of photoinduced changes ultrafast dynamics between single and ensemble nanowires provides great insight into the influence of incident light polarization on different absorption and interaction mechanisms between in well aligned Si nanowire NWsand polarization status of light. The observed anisotropy in single nanowire NWs could allowsenable advanced applications, including such as optical switching and polarization sensitive photo detection, on theor in nanoscale, where directional control and high spatial resolution are much desired.
-/abstract-

Minah Seo,

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Outlines

- **Sample preparation**

  : vapor-liquid-solid-grown SiNWs

- **Ultrafast optical pump-probe spectroscopic measurement**

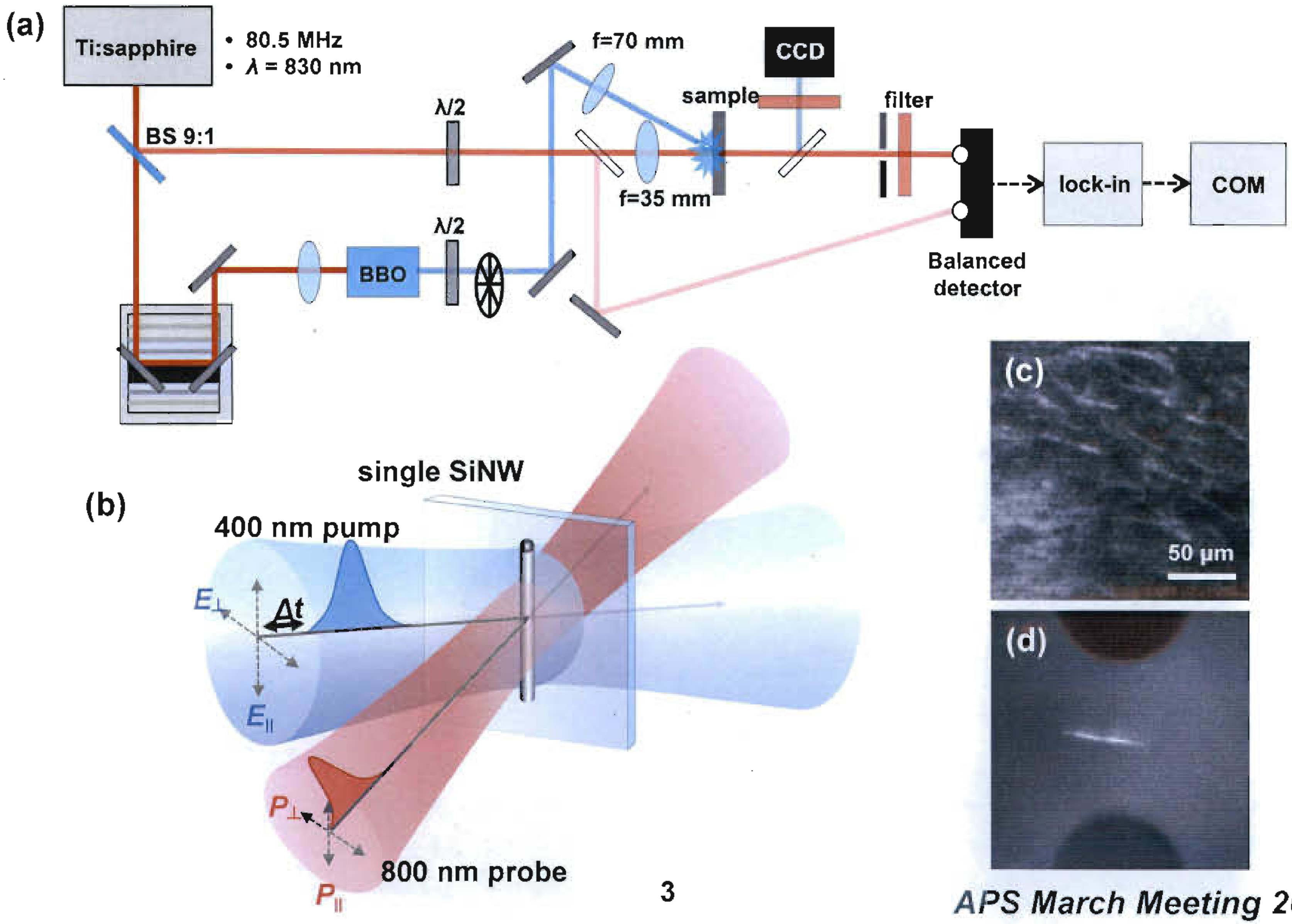
  : femtosecond pump-probe measurments on SiNWs

- **Ultrafast dynamics on both ensemble and single SiNW**

  : Polarization dependent transmission

- **Summary**

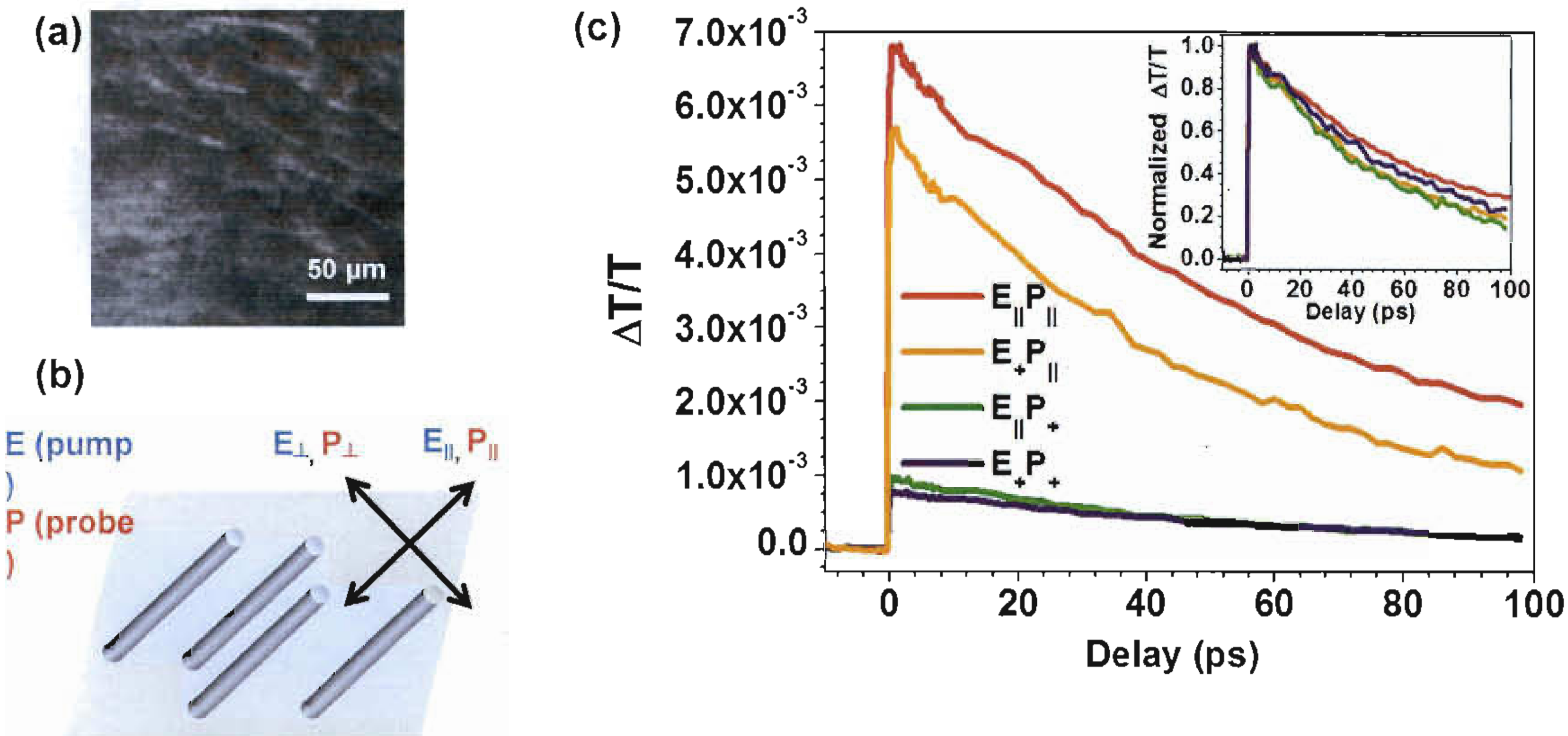
Ultrafast optical pump-probe spectroscopy



Ultrafast dynamics on Ensemble SiNWs

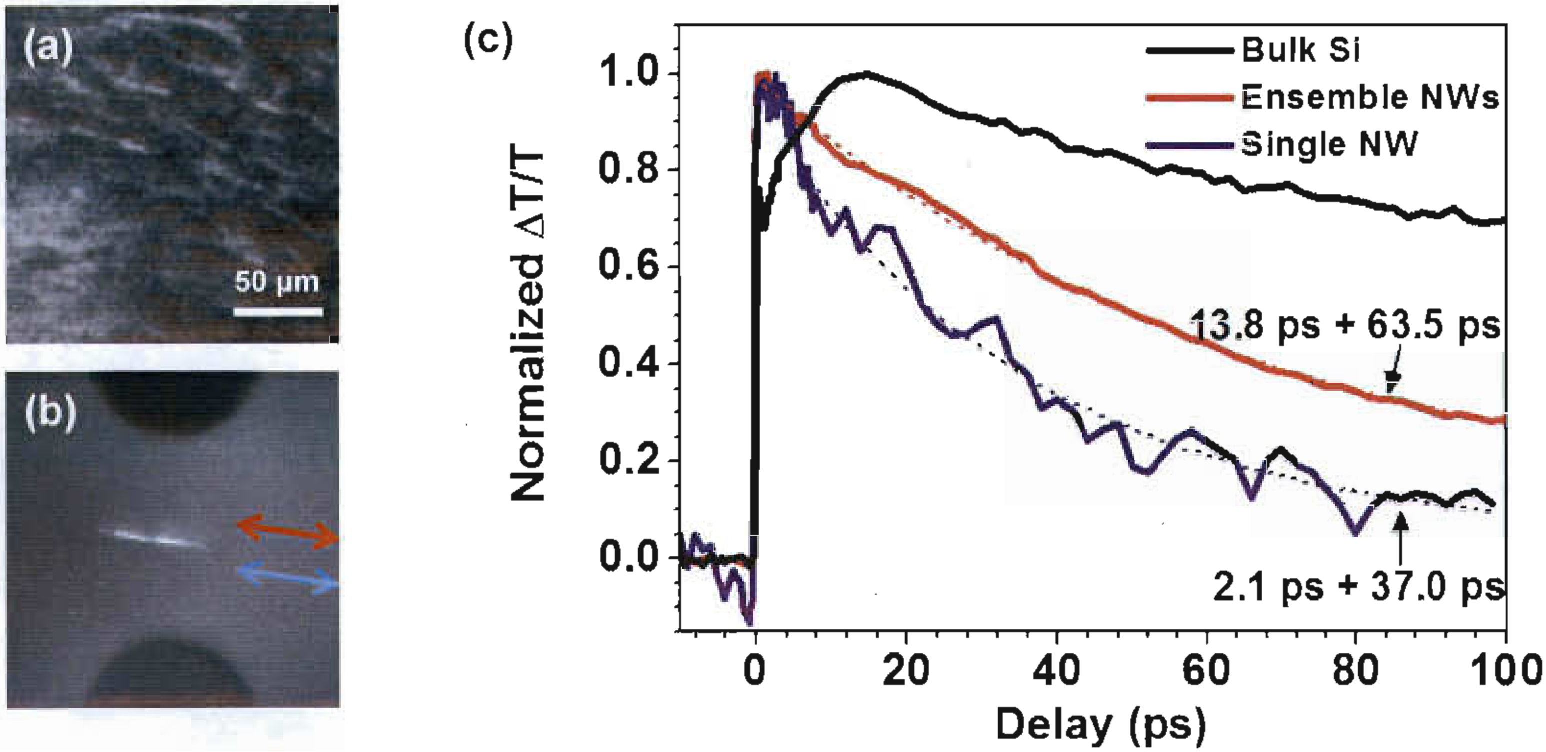
- Polarization dependent transmission measurement on ensemble Si NWs (a).

  Inset in (a) shows normalized transmissions for different polarization combinations with pump and probe on Si en semble NWs and bulk Si.

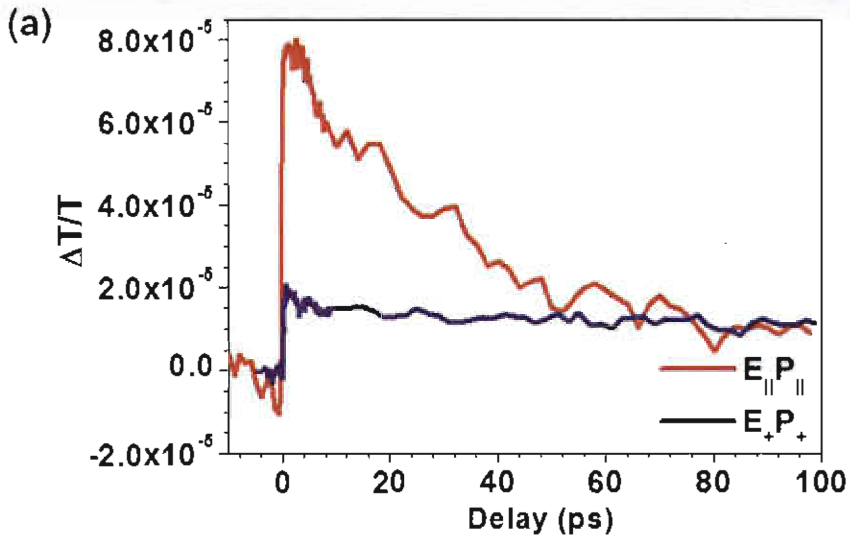


First measurement on single SiNW

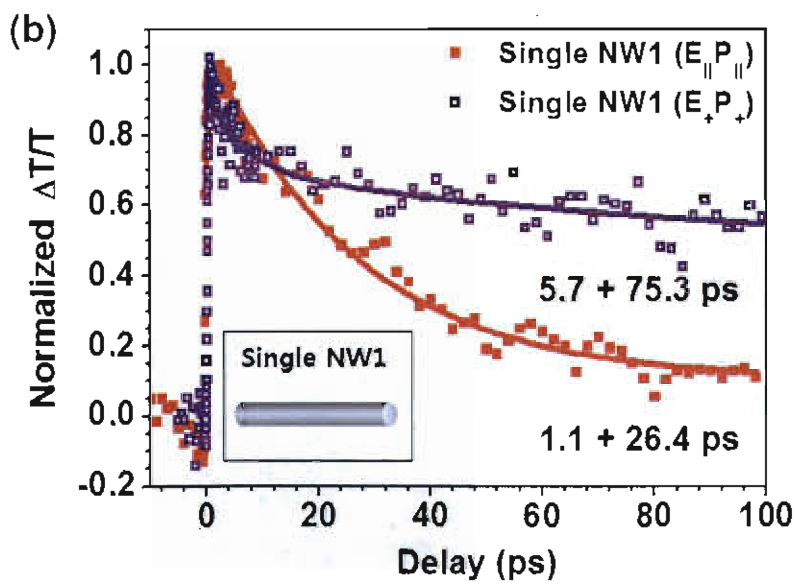
- Comparison of transient carrier dynamics between ensemble- and single-SiNWs, and bulk silicon.
- Polarization for both pump and probe aligned parallel to the NW axis.

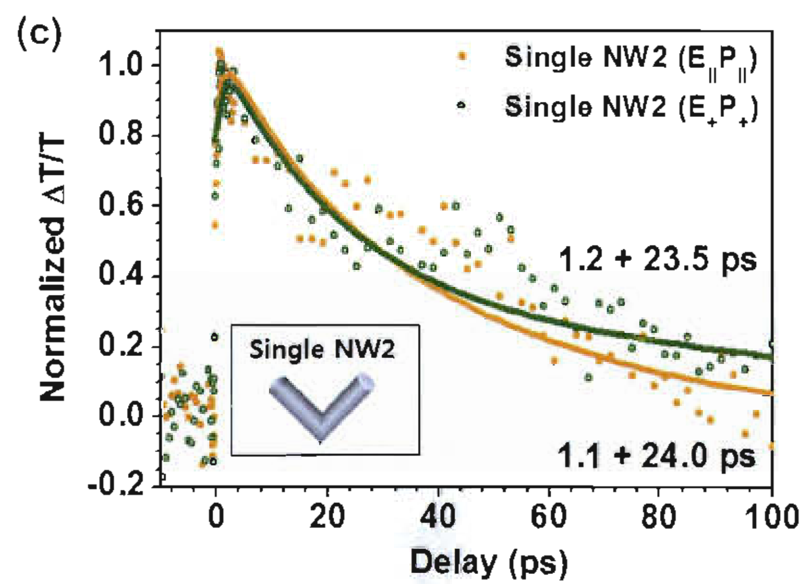


Polarization dependence on single SiNWs



- Pump-induced change in transmission for different pump and probe polarizations in a single SiNW.

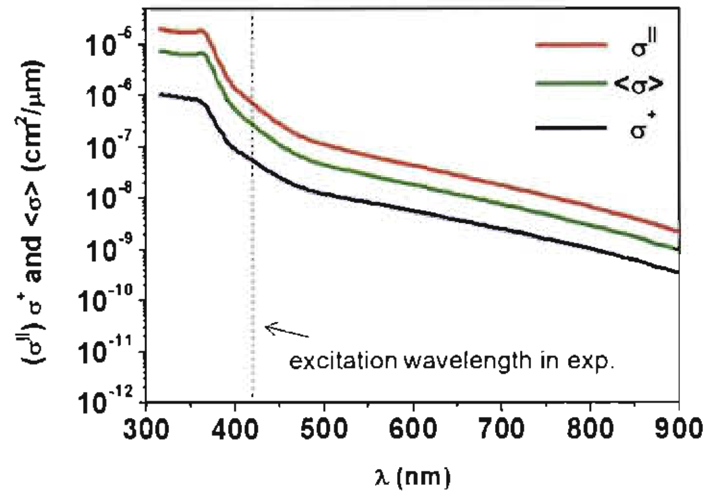




Carrier density calculation

- Absorption cross sections for two different polarization status
- Time-dependent e-h pair density at pump fluences of 11.0 $\mu J/cm^2$

(a)



$$\sigma^{\|}(\omega) = \frac{2\pi a}{Z\varepsilon v} Re\left\{-i \sum_{n=-\infty}^{\infty} \sqrt{\varepsilon(\omega)^*}\,|C_n|^2 J_n(ka) J'^*_n(ka)\right\}$$

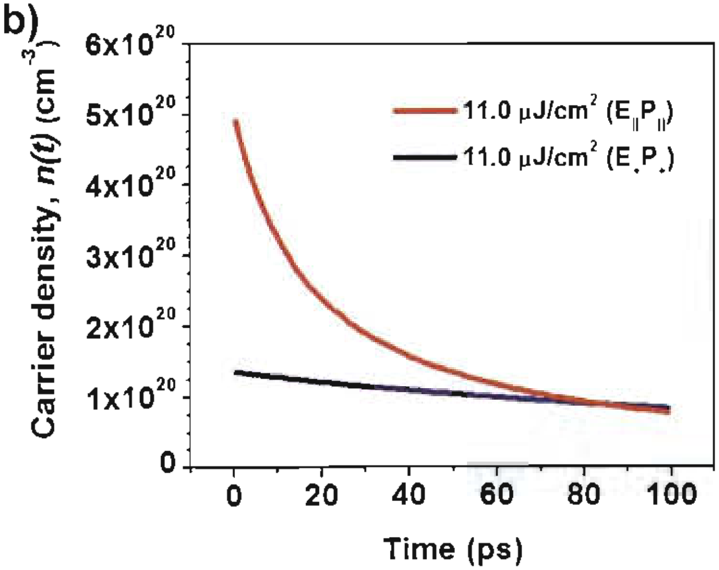
$$\sigma^{+}(\omega) = \frac{2\pi a}{Z\varepsilon v} Re\left\{i \sum_{n=-\infty}^{\infty} \sqrt{\varepsilon(\omega)^*}\,|d_n|^2 J'_n(ka) J^*_n(ka)\right\}$$

$$< \sigma > = \frac{1}{2}\int_0^{\pi} \left(\sigma^{\|} cos^2(\theta) + \sigma^{+} sin^2(\theta)\right) \sin(\theta)\, d\theta = \frac{(\sigma^{\|} + 2\sigma^{+})}{3}$$

R. Ruppin, Opt. Commun. 211, 335-340 (2002)

Jay Giblin, et al., Acs Nano 3, 1979-1987 (2009)

(b)



$$n(t) = \frac{n(0)}{\left(1 + \frac{1}{D-1} C_D n(0)^{D-1} t\right)^{D-1}}$$

$(D > 1)$

n(t): initial carrier density

C_n: Auger constant

Istvan Robel et al., Nano Letters 6, 1344 (2006)