

# Savas Tay

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## Education

*Stanford University*  
Postdoctoral training in Bioengineering,  
(Adviser: Stephen Quake)

*University of Arizona*  
Ph.D. in Optical Sciences  
(Adviser: Nasser Peyghambarian)

*Marmara University*  
B.S. in Physics and Education

## Research Interests

Systems Biology and Microfluidics

Optical control of cellular signaling

Biophotonics and Biomedical Imaging

Optofluidic sensors

## Postdoctoral Research

### *Systems Biology and Microfluidics*

- Investigation of Cell Signaling, Gene Regulatory Networks and Cell Cycle in mammalian cells using high-throughput microfluidic cell culture, time-lapse fluorescence microscopy and mathematical modeling. Below are the questions under investigation:
  - ✓ *How does the cell respond to variation in signal intensity?* I found that cells respond in a discrete (digital) way to variation in extra-cellular TNF concentration by stochastic activation of NF-KB transcription factor and gene expression at the single cell level. A stochastic model was developed that explains all the measured characteristics of this pathway (submitted to Nature).
  - ✓ *Are sister cells always correlated?* Contrary to common belief, I found that transcriptional activity is not necessarily correlated in sister cells. Using experiments and modeling, we show that induced NF-KB oscillations are uncorrelated in sister cells if they divide at early stages where transcript levels are low and susceptible to uneven partitioning during cell division (manuscript in preparation).
  - ✓ *LPS induced NF-KB activation, dynamic range and stochasticity.* I mapped out the complete dynamic range of LPS and live bacteria induced NF-KB activity. Currently I am working on understanding the observed phenomena and developing a mathematical model of this pathway.
  - ✓ *Optical control of genetic pathways.* We are working -in collaboration with Karl Deisseroth- on expressing optically controllable g-protein coupled receptors in

fibroblasts to control the activation of transcriptional pathways like NF-KB all optically.

- Developing a microfluidic cell sorter for use in personalized, bed-side cancer stem-cell diagnostics through single-cell gene expression analysis.

## **PhD Research**

### *Nonlinear Optics, Holography and 3D displays*

- Developed the first updateable holographic 3-D display (published in **Nature**):  
  
This work created record-breaking traffic at the University of Arizona News web site, with more than 20,000 hits in one day. It was covered extensively by: CNN, **Discovery Channel**, *National Geographic*, **BBC**, *NPR (National Public Radio)*, **Photonics Spectra**, *Chemistry World*, **Physics World**, *New Scientist*, *ABC News*, **Photonics.com**, *Daily Telegraph*, **Nikkei Newspaper**, *Optics.org*, **MIT Technology Review**, *Materials World*, **Laser Focus World**, *Die Welt*, **The Herald**, *IEEE Spectrum*, **Science et Vie** and many others.
- Extended Photorefractive Polymers to optical communication IR wavelengths
- Demonstrated novel applications of dynamic holographic materials in imaging and optical communication

### *Photonics and nanotechnology*

- Developed a narrow-band plasmonic thermal IR emitter based on micropatterned diamond like nano-amorphous carbon.
- Invented a method for efficient, low cost generation of terahertz radiation using micro-structured plasmonic structures.
- Invented a melt-processing method for nanocomposite infiltration of nano-holes and developed tunable silicon photonic crystal devices using this technique.

## **PUBLICATIONS**

### **Publications in preparation**

5. **S. Tay**,\* J. Hughey,\* T. K. Lee, T. Lipniacki, S. R. Quake, M. Covert, “ NF-KB dynamics reveal digital activation and analog information processing in cells.” Submitted to *Nature*. (\* equal contribution)
4. **S. Tay**, J. Hughey, T. K. Lee, T. Lipniacki, M. Covert, S. R. Quake, NF-KB is an uncoupled oscillator in sister cells.”
3. **S. Tay**, J. Hughey, T. K. Lee, M. Covert, S. R. Quake, “NF-KB signaling dynamic range in response to LPS and bacteria.”

2. **S. Tay.** “Optics in service of Biology” (invited review article). In preparation for October issue of **Optics and Photonics News (OPN)** OSA.
1. P. A. Blanche, **S. Tay**, R. Voorakaranam, J. Thomas, R. A. Norwood, P. St. Hilaire, M. Yamamoto, N. Peyghambarian, “Two-color updateable holographic display”

### Book Chapters

1. **S. Tay.** “Holographic imaging and visualization” in **Optical and Digital Image Processing—Fundamentals and Applications**, eds. Gabriel Cristobal, Peter Schelkens, Hugo Thienpont, to be published by *Wiley VCH*.

### Review Articles

5. **S. Tay**, N. Peyghambarian, “Updateable holographic 3D displays based on photorefractive polymers” (invited) **Society for Information Display** 24, 07 (July 2008).
4. N. Peyghambarian, **S. Tay**, P. Blanche, R. Norwood, M. Yamamoto, “Refreshable holographic 3D displays” (invited) (Cover article). **Optics and Photonics News (OPN)** OSA, (July 2008).
3. P. A. Blanche, **S. Tay**, P. St Hilaire, R. Voorakaranam, J. Thomas, C. Christenson, R. A. Norwood, M. Yamamoto, N. Peyghambarian, “An updateable holographic display for 3-D visualization” (invited). **IEEE Journal of Display Technology** 4, 424 (2008).
2. **S. Tay** , N. Peyghambarian, “Photorefractive polymers and their applications in photonics” (invited) **Sigma Journal of Engineering and Natural Sciences**, 2005/4, Yildiz Technical University Press, Yildiz-Istanbul (2006).
1. J. Thomas, M. Eralp, **S. Tay**, M. Yamamoto, G. Li, R. Norwood, S. R. Marder, N. Peyghambarian, “Photorefractive polymers with superior performance.” **Optics and Photonics News (OPN)**, OSA, December (2005).

### Peer Reviewed Publications

11. **S. Tay**, P. A. Blanche, R. Voorakaranam, A. V. Tunc, J. Thomas, S. Rokutanda, R. Flores, P. Wang, G. Li, W. Lin, T. Gu, P. St. Hilaire, R. A. Norwood, M. Yamamoto, P. Wang and N. Peyghambarian, “An updateable holographic three-dimensional display.” **Nature** 451, 694 (2008).

This paper was covered by *CNN*, **Discovery Channel**, *National Geographic*, **BBC**, *NPR* (*National Public Radio*), **Photonics Spectra**, *Chemistry World*, **Physics World**, *Photonics Spectra*, **New Scientist**, *ABC News*, **Photonics.com**, *Daily Telegraph*, **Nikkei Newspaper**, *Optics.org*, **MIT Technology Review**, *Materials World*, **Laser Focus World**, *Die Welt*, **The Herald**, *IEEE Spectrum*, **Science et Vie** and many others.

10. **S. Tay**, A. Kropachev, I. E. Araci, R. A. Norwood, T. Skotheim, N. Peyghambarian, "Plasmonic thermal IR emitters based on nano-amorphous carbon." **Applied Physics Letters** 94, 071113 (2009).
9. **S. Tay**, J. Thomas, B. Momeni, P. Hotchkiss, M. Askari, S. Jones, A. Adibi, S. R. Marder, R. A. Norwood and N. Peyghambarian, "Infiltration of 2D photonic crystals with nanoparticle/polymer nanocomposites." **Applied Physics Letters** 91, 221109 (2007).

Also published in *Virtual Journal of Nanoscience and Technology*

8. **S. Tay**, J. Thomas, M. Eralp, G. Li, S. Marder, G. A. Walker, S. Barlow, M. Yamamoto, R. Norwood, A. Schülzgen and N. Peyghambarian, "High performance photorefractive polymer operating at 1550 nm with near video-rate response time." **Applied Physics Letters**, 87, 171105 (2005).
7. **S. Tay**, J. Thomas, M. Eralp, G. Li, B. Kippelen, S. R. Marder, G. Meredith, A. Schülzgen and N. Peyghambarian. "Photorefractive polymer composite operating at the optical communication wavelength of 1550 nm." **Applied Physics Letters**, 85, 4561 (2004).

This paper was covered by *TRN (Technology Research News) magazine*.

6. P. D. van Voorst, M. R. de Wit, H. L. Offerhaus, **S. Tay**, J. Thomas, N. Peyghambarian, K. -J. Boller, "Holographic injection locking of a broad area laser diode via a photorefractive thin-film device." **Optics Express**, 15, 17587 (2007).
5. M. Eralp, J. Thomas, **S. Tay**, G. Li, M. Yamamoto, A. Schulzgen, R. Norwood, N. Peyghambarian, "Efficient photorefractive polymer operating in reflection geometry." **Optics Express**, 15, 11622 (2007).
4. M. Eralp, J. Thomas, G. Li, **S. Tay**, A. Schülzgen, R. A. Norwood M. Yamamoto and N. Peyghambarian, "Photorefractive polymer device with video-rate response time operating at low voltages." **Optics Letters**, 31, 1408 (2006).
3. M. Eralp, J. Thomas, **S. Tay**, G. Li, A. Schulzgen, R. Norwood, M. Yamamoto, N. Peyghambarian, "Submillisecond response of a photorefractive polymer under single nanosecond pulse exposure." **Applied Physics Letters**, 89, 114105 (2006).
2. G. Li, M. Eralp, J. Thomas, **S. Tay**, S. R. Marder, A. Schülzgen, R. A. Norwood and N. Peyghambarian, "All-optical dynamic correction of communication signals using a photorefractive polymeric hologram." **Applied Physics Letters**, 86, 161103 (2005).
1. M. Eralp, J. Thomas, **S. Tay**, G. Li, G. Meredith, A. Schülzgen, N. Peyghambarian, G. A. Walker, S. Barlow, and S. R. Marder, "High performance photorefractive polymer operating at 975 nm." **Applied Physics Letters**, 85, 1095 (2004).

## Conferences

27. **S. Tay**, T. K. Lee, J. Hughey, M. Covert, A. Leyrat, S. R. Quake. "Decoding gene regulatory networks using microfluidics: NF-KB signaling and dynamic range", **SPIE BIOS: Biomedical Optics**, January 2010, San Francisco, CA (INVITED)

26. **S. Tay**, T. K. Lee, J. Hughey, M. Covert, A. Leyrat, S. R. Quake. "NF-KB signaling, dynamic range in response to TNF and LPS", **BMES Annual Fall Meeting**, October 2009, Pittsburgh, PA
25. **S. Tay**, T. K. Lee, J. Hughey, M. Covert, A. Leyrat, S. R. Quake. "NF-KB signaling, dynamic range and stochastic switching", **Q-BIO Conference on Cellular Information Processing**, August 2009, Los Alamos, NM
24. **S. Tay**, T. K. Lee, J. Hughey, M. Covert, A. Leyrat, S. R. Quake. "NF-KB signaling, dynamic range and stochastic switching under TNF and LPS", **International Conference on Systems Biology (ICSB) 2009**, August 2009, Stanford, CA (POSTER)
23. J. Hughey, **S. Tay**, T. K. Lee, M. Covert, A. Leyrat, S. R. Quake. "Diverse signaling responses in under TNF-alpha", **International Conference on Systems Biology (ICSB) 2009**, August 2009, Stanford, CA (POSTER)
22. **S. Tay**, P. A. Blanche, R. Norwood, M. Yamamoto, N. Peyghambarian. "Refreshable holographic 3D displays based on photorefractive polymers." **SPIE Photonics West, Practical Holography**, January 2008, San Jose, CA (INVITED)
21. **S. Tay**, M. Yamamoto, N. Peyghambarian, "An updateable holographic three-dimensional display" **International Conference on Organic Electronics**, 16 June 2008, Eindhoven, Netherlands (INVITED)
20. **S. Tay**, M. Yamamoto, N. Peyghambarian, "An updateable holographic three-dimensional display based on photorefractive polymers" **SID International Symposium**, 18 May 2008, Los Angeles, CA (INVITED)
19. **S. Tay**, A. Kropachev, T. Skotheim, R. A. Norwood, N. Peyghambarian, "Narrow-band thermal mid-IR emitters based on microstructured nano-amorphous carbon" (poster) **SPIE Symposium, Photonics West 19-24 January 2008**, San Jose, CA. (POSTDEADLINE)
18. R. Norwood, **S. Tay**, P. Blanche, R. Voorakaranam, P. St. Hilaire, P. Wang, M. Yamamoto, D. Flores, C. Christenson, N. Peyghambarian. "Photorefractive polymers for updateable holographic displays." **Frontiers in Optics, ACS/OSA**, Sept 22, 2008. San Jose, CA
17. **S. Tay**, J. Thomas, B. Momeni, P. Hotchkiss, M. Askari, S. Jones, A. Adibi, S. R. Marder, R. A. Norwood and N. Peyghambarian, "Polymer nanocomposite infiltration of silicon photonic crystals." **SPIE Symposium, Photonics West 19-24 January 2008**, San Jose, CA.
16. **S. Tay**, A. Kropachev, R. A. Norwood, T. Skotheim, N. Peyghambarian. **International Conference on Molecular Photonics**. "Narrow-band mid-IR thermal emitters based on surface plasmons in microstructured nano-amorphous carbon" August 2007, Friday Harbor Laboratories, University of Washington, Friday Harbor, WA. (POSTER)
15. P. D. van Voorst, H. L. Offerhaus, **S. Tay**, J. Thomas, N. Peyghambarian, K. J. Boller, "Injection locking of a broad area laser diode by holographic four-wave mixing in a photorefractive polymer." **CLEO/QELS 07**, May 2007, Baltimore, ML.

14. **S. Tay**, J. Thomas, M. Eralp, G. Li, J. Winiarz, R. Norwood, A. Schülzgen, S. Marder and N. Peyghambarian, "Photorefractive polymer operating at 1550 nm with 40% diffraction efficiency and 35 ms response time." **SPIE Symposium on Optics & Photonics**, 31 July-4 August 2005, San Diego, CA. (INVITED)
13. G. Li, M. Eralp, J. Thomas, **S. Tay**, R. A. Norwood, M. Yamamoto, N. N. Peyghambarian, "Efficient local fixing of photorefractive polymer holograms recorded with CW and pulsed beams." **SPIE Symposium on Optics & Photonics**, 13 August 2006, San Diego, CA. (INVITED)
12. **S. Tay**, R. A. Norwood, H. Sumimura, A. Kropachev, J. Thomas, N. Peyghambarian, T. Skotheim, J. H. Moon, S. Yang, "Infiltration of photonic crystals with organic materials." **OSA Annual Meeting**, 8-12 October 2006, Rochester, NY. (POSTDEADLINE)
11. **S. Tay**, J. Thomas, M. Eralp, G. Li, B. Kippelen, S. Marder, G. Meredith, A. Schülzgen and N. Peyghambarian, "Photorefractive polymers sensitized at 1550 nm through two-photon absorption with non-destructive readout." **SPIE International Symposium**, 3-8 August 2003, San Diego, CA. (POSTDEADLINE)
10. J. Thomas, M. Eralp, **S. Tay**, G. Li, M. Yamamoto, R. Norwood, A. Schülzgen, and N. Peyghambarian. "Photorefractive polymers with sub-millisecond response time." **SPIE Symposium on Optics & Photonics**, 13 August 2006, San Diego, CA.
9. M. Eralp, J. Thomas, **S. Tay**, G. Li, R. A. Norwood, N. Peyghambarian, "Photorefractive polymer in reflection geometry with large efficiency." **SPIE Symposium on Optics & Photonics**, 13 August 2006, San Diego, CA.
8. P. Wang, M. Yamamoto, J. Thomas, M. Eralp, **S. Tay**, G. Li, R. A. Norwood, N. N. Peyghambarian, "High-performance 532-nm sensitive photorefractive polymeric composites." **SPIE Symposium on Optics & Photonics**, 13 August 2006, San Diego, CA.
7. R. A. Norwood, H. Sumimura, **S. Tay**, K. Yamnitsky, A. Kropachev, J. Thomas, N. Peyghambarian, J. H. Moon, S. Yang, T. Skotheim. "New organic infiltrants for 2-D and 3-D photonic crystals." **SPIE Symposium on Optics & Photonics**, 13 August 2006, San Diego, CA.
6. G. Li, M. Eralp, J. Thomas, **S. Tay**, J. Winiarz, A. Schülzgen, R. Norwood, and N. Peyghambarian, "Photorefractive adaptive optics for dynamic correction of atmospheric-like wavefront aberrations." **SPIE Symposium on Optics & Photonics**, 31 July-4 August 2005, San Diego, CA.
5. M. Eralp, J. Thomas, G. Li, J. Winiarz, **S. Tay**, A. Schülzgen, R. Norwood and N. Peyghambarian, "Photorefractive polymer device operating at practical voltages", 89th **OSA Annual Meeting**, 2005, Tucson, AZ. (INVITED)
4. J. Thomas, **S. Tay**, J. Winiarz, M. Eralp, G. Li, S. R. Marder, R. A. Norwood, A. Schülzgen and N. Peyghambarian, "Recent advances in two-photon photorefractive polymers." **OSA Annual Meeting**, Frontiers in Optics, 2005, Tucson, AZ.

3. **S. Tay**, J. Thomas, M. Eralp, G. Li, B. Kippelen, S. Marder, G. Meredith, A. Schülzgen and N. Peyghambarian. "Novel infrared sensitive photorefractive polymer composite." **2004 CLEO/IQEC**, 2004, San Francisco, CA.
2. J. Thomas, M. Eralp, **S. Tay**, G. Li, S. R. Marder, G. Meredith, A. Schülzgen, and N. Peyghambarian, "Near infrared photorefractive polymer composites with high diffraction efficiency and fast response time." **SPIE International Symposium**, August 2004, Denver, CO.
1. M. Eralp, **S. Tay**, J. Thomas S. Marder, G. Meredith, A. Schülzgen and N. Peyghambarian. "Photorefractivity with non-destructive readout at near-infrared wavelengths." **OSA Annual Meeting**, Frontiers in Optics, 2003, Tucson, AZ.

### **Patents**

1. Tunable radiation emitting structure has discontinuous conducting interface with periodic or quasi-periodic features that is formed on substrate for emitting narrowband terahertz radiation (US Patents WO2009009181-A2; WO2009009181-A3)
2. System and method using a voltage kick-off to record a hologram on a photorefractive polymer for three-dimensional display and other applications. (US Patent 12/185,087)
3. New Technique for Polymer Infiltration of Photonic Crystals (University of Arizona provisional disclosure)
4. Infra-red emitters based on nanoamorphous carbon (University of Arizona provisional disclosure)

### **Invited Seminars**

14. Molecular and Cellular Biology Department, University of Arizona, November 2009.
13. Bilkent University, Department of Physics, Ankara, December 2008.
12. Harvard University, Engineering and Applied Science, Boston, March 2008.
11. University of Illinois, Urbana-Champaign, Electrical Engineering, Urbana, March 2008.
10. Caltech, Electrical Engineering, Pasadena, March 2008.
9. Stanford University, Bioengineering Department, Stanford, February 2008.
8. Los Alamos National Laboratory, Center for Integrated Nanotechnologies, Los Alamos,
7. Cornell University, Department of Applied Physics, Ithaca, December 2007.
6. Princeton University, Department of Electrical Engineering, Princeton, December 2007.
5. Bilkent University, Department of Physics, Ankara, December 2006.
4. TUBITAK Marmara Research Center, Materials Institute, Gebze, January 2006.

3. Izmir Institute of Technology, Department of Physics, Izmir, December 2005.

2. Izmir Institute of Technology, Faculty of Science, Izmir, January 2004.

1. Koc University, Department of Physics, Istanbul, December 2003.

## **Employment**

*Research Associate*, Department of Bioengineering, **Stanford University** and **Howard Hughes Medical Institute**

*Postdoctoral Research Associate*, College of Optical Sciences, **University of Arizona**

*Graduate Research Associate*, College of Optical Sciences, **University of Arizona**

*Graduate Teaching Assistant*, Physics Department, **Iowa State University**

## **Professional Service**

Organizing Committee Member, International Conference on Systems Biology (ICSB) 2009, Stanford, CA

Served as session chair at the International Conference on Organic Electronics (ICOE 2008), Eindhoven, Netherlands

Reviewed papers for *Polymer and Colloid Science*, *Optics Express*, *Applied Optics*, *Optics Communications*

Reviewed a research grant for the Netherlands Foundation for Fundamental Research on Matter (FOM).

## **Teaching**

- *Graduate Teaching Associate*, (2006), College of Optical Sciences, **University of Arizona**: Opti 507 (Solid State Optics)
- *Graduate Teaching Assistant*, (2002), Department of Physics, **University of Arizona**: PHYS 141 (Introduction to Mechanics) (recitation and lab)
- *Graduate Teaching Assistant*, (2001) Physics Department, **Iowa State University**: Physics 221 (Classical Mechanics), Physics 222 (Electricity and Magnetism) (recitation and lab)
- *Physics Teacher*, (2000) **International Computer High School**, Constanta, Romania: Classical Mechanics, Modern Physics, National Physics Olympiads study group.

## References

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