Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission

Eli Yablonovitch
REGENTS OF THE UNIVERSITY OF CALIFORNIA THE

02/02/2016
Final Report

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Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission

The goal of this project was to show that spontaneous emission could be accelerated by an optical antenna, to the point that it would become faster than stimulated emission. This would require spontaneous emission acceleration by 200x. The project has succeeded, both for optically pumped spontaneous emission, and electrically pumped spontaneous emission. We have observed a speedup of >300x, and we project a speedup of 2500x at an optimal antenna gap spacing, ~10nm. We intend to present a publicity release based on this accomplishment. Actually, a narrower antenna gap would result in further speedup, but at progressively lower efficiency. The reason for this is that an oscillating atomic dipole induces optical frequency currents in the adjacent parts of the metal antenna. These currents are subject to Ohmic losses, cutting the antenna efficiency. Thus we have been encouraging our competitors to place a secondary requirement on spontaneous emission acceleration. It should be accompanied by antenna efficiency of >50%.
Nanophotonic Devices: Spontaneous Emission Faster than Stimulated Emission
FA9550-15-1-0024

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We believe that these new types of spontaneous emission optical sources, acting as antenna enhanced Light Emitting Diodes, can enable short distance optical communication, including possibly on-chip optical interconnect. One of the motivations for this is the LED’s, unlike lasers, require no threshold current, and could be much more energy efficient. Another motivation is that the antenna LED can be perhaps 10 times faster than the laser. We are continuing to investigate other aspects of the antenna-LED communications link, from the viewpoint of the optical detector requirements, with the aim of enabling a complete optical communications channel at the nano-scale.

Publications during past year:

Patents during past year:

Invited Presentations during Past Year:
1. Oliver Buckley Condensed Matter Physics Prize, 2015, American Physical Society, for “seminal achievements in solar cells, strained lasers, & photonic crystals.”
2. Present Invited Papers at AVS and OSA Conferences, San Jose, CA, October 2015

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Awards Past Year:
1. Isaac Newton Medal & Prize, 2015, the highest award of the UK Institute of Physics, for “his visionary and foundational contributions to photonic nanostructures.”
AFOSR Deliverables Submission Survey

Response ID: 5758

1. Report Type
   Final Report

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Organization / Institution name
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Grant/Contract Title
   The full title of the funded effort.
   Nanophotonic Devices; Spontaneous Emission Faster than Stimulated Emission

Grant/Contract Number
   AFOSR assigned control number. It must begin with "FA9550" or "F49620" or "FA2386".
   FA9550-15-1-0024

Principal Investigator Name
   The full name of the principal investigator on the grant or contract.
   Eli Yablonovitch; Ming Wu

Program Manager
   The AFOSR Program Manager currently assigned to the award
   Harold Weinstock

Reporting Period Start Date
   11/01/2014

Reporting Period End Date
   10/31/2015

Abstract
   The goal of this project was to show that spontaneous emission could be accelerated by an optical antenna, to the point that it would become faster than stimulated emission. This would require spontaneous emission acceleration by 200x. The project has succeeded, both for optically pumped spontaneous emission, and electrically pumped spontaneous emission. We have observed a speedup of >300x, and we project a speedup of 2500x at an optimal antenna gap spacing, ~10nm. We intend to present a publicity release based on this accomplishment.

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Archival Publications (published) during reporting period:


Changes in research objectives (if any):

None

Change in AFOSR Program Manager, if any:

None

Extensions granted or milestones slipped, if any:

None

AFOSR LRIR Number

LRIR Title

Reporting Period

Laboratory Task Manager

Program Officer

Research Objectives

Technical Summary
### Funding Summary by Cost Category (by FY, $K)

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### Report Document

### Report Document - Text Analysis

### Appendix Documents

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