ND*nano* Undergraduate Research Fellowship (NURF)
2012 Project Summary

1) Student name: Thomas Butler
2) Faculty mentor name: Prof. Scott Howard and Prof. Anthony Hoffman
3) Project title: Optical Quilt Packaging
4) Briefly describe any new skills you acquired during your summer research:
   - Working with Electromagnetic field simulation software.
   - Giving regular presentations to fellow group members.
   - Presenting and designing graphs and figures.
   - Designing and simulating optical and mid-IR waveguide gemetries.
   - Learning about fabrication process flow and equipment.
   - Clean room training – photolitography, etching, etc.
5) Please briefly share a practical application/end use of your research:
   This work will hopefully see use in reducing the cost and size of photonic circuits, which can be used in applications such as chemical and biological sensing, communications and computing.

Project summary:

Photonic devices have myriad applications in biological and chemical sensing, computing and communications. The integration of these photonic devices into circuits can provide improved performance over current technology, as well as reduce both device size, cost and even enable new functionality. However a significant challenge in integration is the different photonic devices require different materials: for example an InP-based laser may have to transfer light to an SOI (silicon-on-insulator) waveguide circuit containing other components, such as an interaction space between the light and a liquid being tested. Then need for different substrates and fabrication processes leads to the need for an efficient packaging solution.

Over the summer I worked on performing preliminary numerical and experimental work on integrating an InP-based quantum cascade laser with an SOI waveguide, using Quilt Packaging (QP)[1]. Quilt packaging is currently used as an electronic packaging system, providing good signal transmission between electronic devices on different substrates and an overall small chip footprint, but little work has been done towards using this technology for photonic applications. I investigated the limitations of QP for photonic circuits by simulating the transmission properties of coupled waveguides using the numerical software package MEEP[2] (MIT Electromagnetic Equation Package), as well as the limitations. To mitigate the anticipated alignment deviations in fabrication, the effect of introducing an index matching material to the inter-chip gap was simulated. The viability of incorporation these index matching materials was also experimentally investigated by fabricating SOI waveguides in the ND nanofab and examining various index matching materials for uniform filling of the gap. The future of this work lies in constructing a QP set of waveguides that can ensure sub-micron alignment across many waveguides and different substrates (InP, GaAlAs, SOI, Si).

[1] – Indiana Integrated Circuits (IIC) - http://www.indianaic.com/
[2] – MEEP - http://ab-initio.mit.edu/wiki/index.php/Meep