II-VI INFRARED RESEARCH DEVELOPMENT

Realization of High Operating Temperature LW-HgCdTe

SOED and AC&M TEAM

S&T Campaign: Materials Research
Photonics
Imaging Sensors & Optics

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Research Objective

- **Demonstrate background limited in performance (BLIP) of long-wave (LW) HgCdTe (λ_c ~10.5 μm) at twice the operating temperature of current 80K HgCdTe Technology**
  - ➢ **Provide cryogenic-like LWIR devices performance at much higher temperatures**
  - ➢ **Physics allows BLIP close to 200K for LW**

What does this offer to Warfighter

- **Half the cool down time (5 mins) of the sensor for greater battle field survivability with faster first "image out"**
- **Less than half the power consumption (2 Watts vs 5 Watts). Hence, longer cooler lifetime**
  - ➢ **Leads to dramatic reduction in size, weight, power, and cost (SWAP-C)**

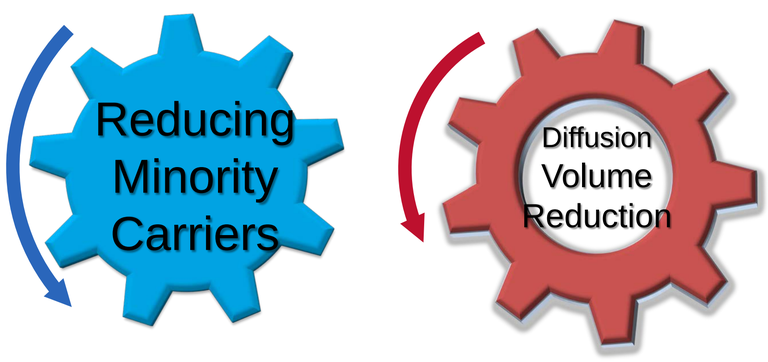
ARL Unique Approach

- **Exploit full depletion using:**
  - ➢ **Advance models to design and optimize heterostructure devices**
  - ➢ **MBE to grow advanced heterostructures**
  - ➢ **Resonant cavities to exploit thin architectures and to recover absorption**
    - ✓ **Take advantage of unique HgCdTe not limited by defects**
- **Key elements:**
  - ➢ **Very thin absorber ~ 1 μm (x10 lower J_d) and fully depletable**
  - ➢ **Compatible with present planar architectures**
  - ➢ **Recover QE with resonant structures**

$$I_{sat} = \frac{qp_{no}}{\tau} dA_P \quad \text{Amps}$$

Depends on Material T(K)

Depends on Device architecture

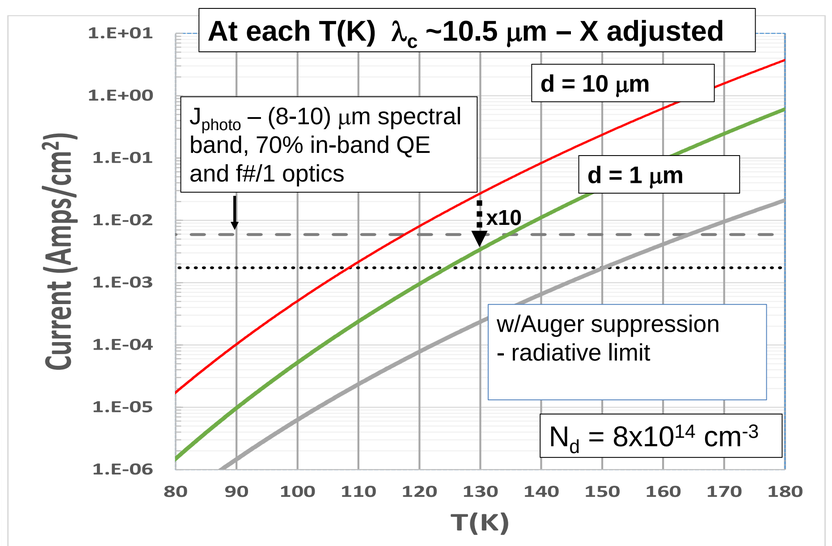


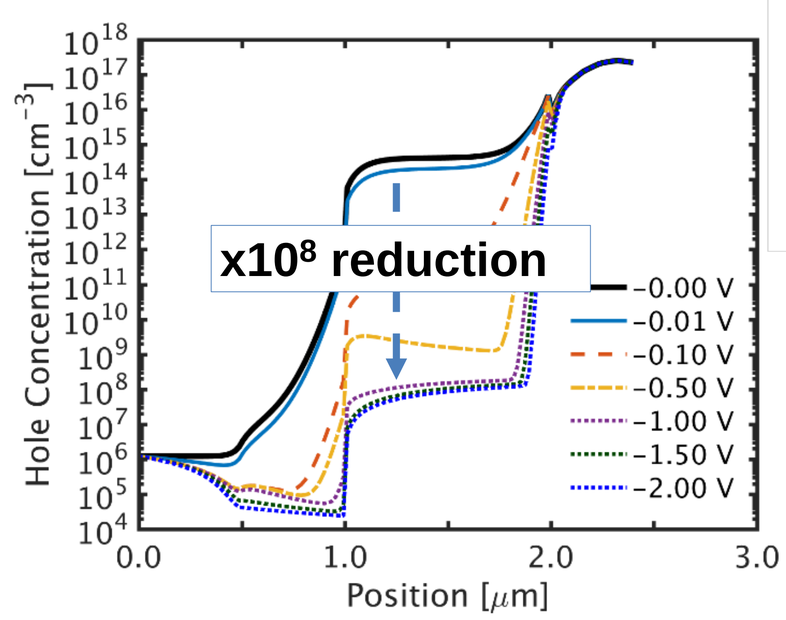
ARL Facilities and Capabilities Available to Support Collaboration

- **Center for Semiconductor Materials & Device Modeling**
  - ➢ **Utilize numerical (1D to 3D) models to develop, realize, improve, validate, educate & transition**
  - ➢ **Initially, without building parts simulating through modeling of various Cd, doping profiles, junction locations, etc.**
- **In-house HgCdTe MBE growth capabilities**
- **II-VI Materials & Devices Team's unique characterization capabilities**
- **ARL's infrastructure fab facilities**
  - ➢ **Full suite of processing capabilities including state-of-art lithography, metal deposition, dry etching, etc.**

Challenges

- **Analytical models cannot accurately model complex device architectures**
  - ➢ **Physics-based 1D to 3D numerical simulations required to understand depleted structures especially in the "intrinsic temperature" regions**
- **Achieving fully depleted absorber especially at "intrinsic temperature" regions**





Accurate modeling indicates drastic reduction in Minority Carriers in the absorber region – Auger Suppression