DUO Optoelectronics

Turn nuclear waste into low-cost optoelectronic devices

BACKGROUND & MOTIVATION

- *Depleted uranium oxide (DUO), is an abundant and cheap waste product of nuclear fuel enrichment process*
- *Its supply will grow with the expected growth of the nuclear energy industry*
- *Solutions for reduction of the stockpile are needed*
- *DUO films have properties appealing for use in low-cost optoelectronic devices (solar cells, detectors, etc.) particularly for use in harsh environments*

INNOVATION

We propose to develop a proof-of-concept uranium photodiode.

- *We have developed methods for rapid and cheap deposition of DUO as a thin film on various substrates*
- *Optical and electronic properties of the film can be tuned by variations in the deposition conditions*
- *This process will be used to form p-n junctions and fabricate proof-of-concept optoelectronic devices. DUO p-n junctions have not yet been demonstrated*
- *Thin uranium oxide film fabrication capability can be readily included to a standard nuclear fuel fabrication process.*

DESCRIPTION

We will characterize opto-electronic properties of uranium oxide films (energy gap, absorptivity,…)

We will fabricate and characterize DUO photodiode

DUO Films Production:

- *The uranium oxide films will be fabricated at the Target Fabrication Facility using the technique recently developed at LANL [I.O. Usov et al., J. Nucl. Mater. 437 (2013) 1]*
- *Undoped uranium oxide has p-type conductivity. To achieve n-type conductivity we will dope it with elements from the III-group of the Periodic Table (Al and B) substituting for oxygen.*

Colors of DUO films controlled by deposition conditions

Films Characterization and device fabrication:

- *Understanding of optical properties of uranium oxide is limited [Meek et al., Mater. Letts 59 (2005) 1085; Schoenes, J. Appl. Phys. 49 (1978) 1463]; with band gap estimated to be in the range 1.5 – 2.5 eV – optimal for use in optoelectronics.*
- *The band gap likely depends on, and can be controlled by the oxygen content, resulting in different oxide phases (UO_2, U_3O_7, U_3O_8, UO_3).*
- *Optical characterization of various oxide films, device fabrication and characterization will be done at Dr. Sykora's laboratories using approaches developed previously [e.g., M. Sykora et. al., ACS Nano. 2010, 4,6377.]*

Current Technology Readiness Level (TRL) 3

We have a great deal of experience in uranium oxide films growth and characterization, as well as optoelectronic devices fabrication and characterization.

ANTICIPATED IMPACT

Possible path to reduction of nuclear waste stockpile with optoelectronics benefit.

- *Immediate potential sponsors include DOE and nuclear energy industry, who are searching for civilian solutions for reduction of depleted uranium stockpile.*
- *Excellent radiation tolerance of uranium oxide to bombardment with energetic particles, makes it attractive for exploitation in optoelectronics .*
- *Successful demonstration of p-n junction device will open an opportunity to make radiation-hard electronic devices.*

PATH FORWARD

Technology development:

1) *Characterize optical properties (e.g., band gap value, absorptivity,…) as a function of oxygen content.*
2) *Make p- and n-type uranium oxide material.*
3) *Fabricate proof-of-concept DUO phitodiode and characterize its performance.*
4) *Anticipated TRL at project end is 4 or 5*

Potential end users:

- *DOE, DOD, Nuclear energy industry, and NASA*

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