**Abstract:**
Our research was focused on studying the growth and optical characteristics of YbFe₂O₄ thin films. YbFe₂O₄ (YbFO) samples were prepared by a solid state reaction. The stoichiometric proportions of Yb₂O₃, Fe₂O₃, and Fe₂O₄ powders were mixed and ground using a mortar and pestle, then pressed into pellets of about 3g and 0.5 inch diameter each using a hydraulic press. The pellets were then sintered in the furnace at 1000°C for 12 hours. After sintering, the pellets were ground, pressed and sintered for a second and sometimes third time. To make the YbFO thin films, we used an electron beam deposition method. The pellets were placed into crucibles and the target pellet was heated by an electron beam for about an hour. The YbFO pellet slowly evaporates onto YSZ and sapphire substrates heated at 850°C until the desired thickness was reached. YbFO thin films were annealed for 3 hours at 600°C. Reflectance and transmittance versus wavelength (200-3000 nm) of YbFO thin films were measured at temperatures between 10 K and 400 K using spectrometers. The optical data of YbFO show several electronic peaks associated with the intra (Fe 3d to d) and inter (O 2p to Fe 3d, Yb 6s, and 5d) atomic electronic transitions. Moreover, the optical properties change as temperature changes, suggesting a strong temperature dependence.

**Objectives:**
- Growth of YbFe₂O₄ thin films.
- Study growth conditions, such as O₂ partial pressure, substrate temperature, annealing process, and so on.
- To understand their optical and electronic characteristics.

**Materials:**
- Ytterbium (III) Oxide - Yb₂O₃
- Iron (II) Oxide - FeO
- Iron (III) Oxide - Fe₂O₃
- (111) YSZ c-axis sapphire substrates
- Liquid Nitrogen for low temperature
- Ethanol and Acetone for cleaning

**Equipment:**
- Die & Hydraulic press
- Electric muffle furnace with temperature gauge (see left image)
- 3kW electron-beam evaporation system with substrate heater (see right image)
- Fiber Optic Spectrometer and UV-3101-PC Shimadzu Spectrophotometer
- Ultra high resistance meter
- Continuous flow optical cryostat and optical cryostat coupled with closed-cycle refrigerator
- Turbo molecular pump

**Experimental Methods**

**Experimental Details:**
- The pellets were prepared by using the following chemical formula.
- Stoichiometric proportions of powders were combined and ground with a mortar and pestle, then pressed in a hydraulic press (20 MPa).

\[
\begin{align*}
\text{Yb}_2\text{O}_3 + 2\text{FeO} + 2\text{Fe}_2\text{O}_3 &\rightarrow 2\text{YbFe}_2\text{O}_4 \\
\text{Yb}_2\text{O}_3 &\rightarrow (173.04 \times 2 + (15.999 \times 3)) = 376.077 \text{ g/mol} \\
\text{FeO} &\rightarrow (58.847 \times 1 + (15.999 \times 1)) = 71.846 \text{ g/mol} \\
\text{Fe}_2\text{O}_3 &\rightarrow (58.847 \times 2 + (15.999 \times 3)) = 159.691 \text{ g/mol} \\
\end{align*}
\]

- Pellet weight = 3.0 grams and 0.5” diameter
- Pellets were sintered at 1000°C for 12 hours
- Pellets were ground and sintered again to allow the compound formation. Color of the pellets changed after sintering, which is an indication that the compound has changed too.

**Results and Discussion**

**XRD Patterns of Pellet and Thin Film**

**Thin Film Deposition:**
- 3 kW beam system with the base vacuum pressure of ~1.0 × 10⁻⁶ Torr
- Mechanisms and liquid nitrogen cooled diffusion pumps were used to achieve the high-vacuum in the chamber
- Evaporation process ran for approximately 2 hours
- The substrate temperature was kept constant at ~850°C
- Thin films with a thickness ranging from 50 to 120 nm were deposited
- A quartz-crystal thickness monitor was used to measure the thickness of thin films deposited onto the substrate
- Thin films were annealed at ~600°C for 3 hours to improve the quality of the film

**Conclusions**
- YbFe₂O₄ pellets were prepared by a solid state reaction.
- We successfully deposited polycrystalline YbFe₂O₄ thin films on YSZ and sapphire substrates by electron beam deposition.
- Finding appropriate substrate temperature, oxygen partial pressure, and deposition rate is key in depositing YbFe₂O₄ thin films.
- The absorption spectra of YbFe₂O₄ show multiple electronic excitations associated with the intra and inter atomic electronic charge transfer transitions.

**Acknowledgements**
This project was supported by the National Science Foundation (DMR-1406766)