STEPS Students Report

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From April 16th to May 17th , 2018 I was participating in Students and Researchers Exchange Program in Sciences (STEPS). This period I joined research group of prof. Tetsuya Hasegawa, which belongs to Solid State chemistry laboratory of Department of chemistry.

$FeMoO_3$ is a mixture of Fe_2MoO_4 and $Fe_2Mo_3O_8$ phases. However, it is expected that new phase of $FeMoO_3$ can be obtained by using thin film growth technique. The purpose of my work in Tokyo was to try to obtain this new phase of $FeMoO_3$.

In order to obtain $FeMoO_3$ thin epitaxial film, PLD method was used. The conditions of the experiment are as follows:

Temperature=600^0C

Pressure (Ar) = 10^{-4} Torr

Laser energy = 12 mJ

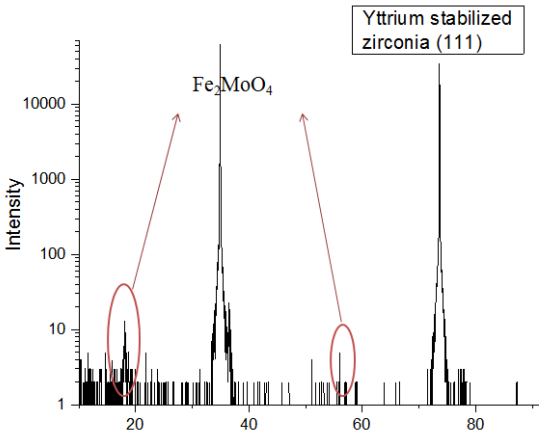
Laser frequency = 5 Hz

Time = 2h

PLD Target = $FeMoO_3$

There were 10 substrates used:

$MgAl_2O_4$ (100)	Al_2O_3 (0001)
$SrTiO_3$ (001)	$SrTiO_3$ (111)
$LaSrAlO_4$ (001)	YSZ (111)
$LaSrAlO_4$ (001)	$CaNdAlO_4$ (001)
YSZ (111)	TiO_2 (100)

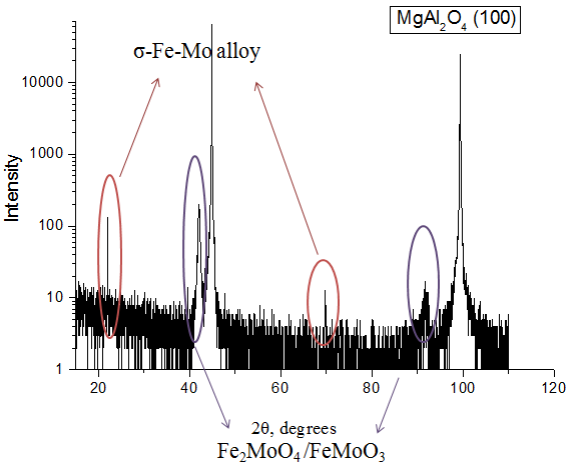


Pic.1 XRD of film on YSZ substrate

Films on the most of substrates used didn't show crystallinity. XRD results showed that almost all films are amorphous except two samples.

XRD of sample, where YSZ was used as a substrate, showed weak peaks. Based on database we can suggest that this peaks are corresponded to peaks of Fe_2MoO_4. (pic.1)

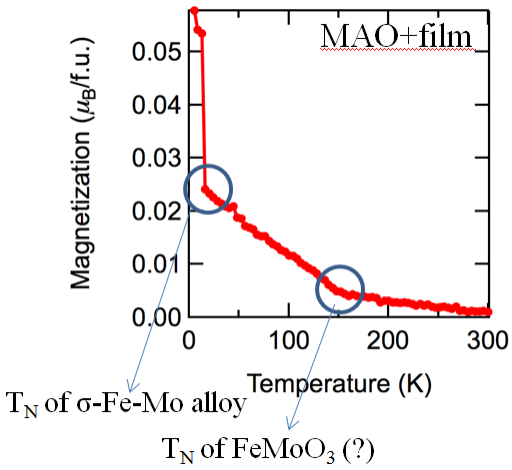
Better results we obtained on sample, where MAO was used as a substrate. We can see 4 peaks. The shape of this two peaks is different from the shape of another two peaks. A couple of very sharp peaks is suggested to be Fe-Mo-alloy. Meanings of another two peaks are also very close to meanings of Fe_2MoO_4 peaks. So, the experiments with a lot of different substrates using and XRD results allowed us to determine a spinel structure of obtained film. (pic.2)



Pic.2 XRD of film on MAO substrate

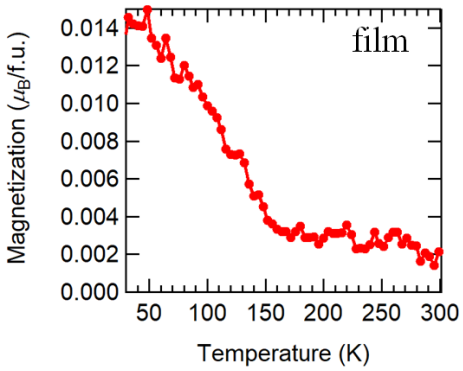
But being based only on XRD we can't make a clearly conclusion that we obtained Fe_2MoO_4 because this types of compounds ($FeMoO_3$ and Fe_2MoO_4) have the same structure, so we can't distinguish them. We can prove that we obtained $FeMoO_3$ if we will fabricate Fe_2MoO_4 and compare XRD results.

Magnetic properties of the most successful sample were investigated. Hysteresis loop proved ferromagnetic nature of compound obtained. On the magnetization-temperature dependence we can see two transitions. (pic.3)



Pic.3 Magnetization-temperature dependence of the best sample

The first one is a transition of Fe-Mo-alloy. The second one is suggested to be $FeMoO_3$ because the magnetization-temperature dependence of Fe_2MoO_4 is different from dependence we have obtained. So it also can't be strong evidence of $FeMoO_3$ film obtaining, but we can't say that we obtained Fe_2MoO_4 either. It should be noted that even after Neel temperature achieving, magnetization is still decreasing. On the picture 4 you can see magnetization-temperature dependence of film obtained without background of substrate. It almost doesn't decrease. So, we can say that at the temperature above 160 K only substrate influences on the shape of curve.



Pic.4 Magnetization-temperature dependence of obtained film

Based on difference in Neel temperature and on difference of octahedral and tetragonal sites ratios of $FeMoO_3$ and Fe_2MoO_4 we can suggest that we have obtained $FeMoO_3$ thin film. But all before-mentioned explanations are only hypothesis. It is necessary to do some additional research work to try to prove $FeMoO_3$ obtaining.

To sum up, 3 experiments of PLD deposition with different substrates were carried out. XRD measurements showed two substrates, which can be used for $FeMoO_3$ thin films growing technique.

Magnetic properties were investigated. Based on magnetization-temperature dependence we determined Neel temperature of film we have obtained. This temperature is 160K.

I would like to thank prof. Tetsuya Hasegawa and all members of his laboratory for this experience. Thank you for letting me work with you even in such a short time, for support and help. You are truly professionals in your field of research. Also I would like to say thanks to STEPS program for this great opportunity to see amazing Japan, both modern and traditional, to find friends and to obtain great professional and cultural experience!