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Nano-order depth control in magnetic grating

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Dicing saw is typically used to cut semiconductor wafers and other substrates. In contrast, magnetic materials have been mechanically micro-fabricated utilizing the dicing saw in our studies [1,2]. This is because the latest machines possess extremely high cutting accuracy. In particular, the vertical accuracy of a few tens of nm is a prominent advantage in comparison with several lithography techniques. Thus, our interest recently focuses on the depth control in the micro-fabricated magnetic materials.

In the present work, the research aim was set to prepare the apodized yttrium-iron-garnet (YIG) gratings with nano-order depth modulation.

The periodic gratings were carved on the surface of the YIG single crystal films by a high-precision dicing saw, Disco DFD6340. Ultra-thin diamond blades provided excellent cutting results. The actual thickness and length of the blades were 15 and 380 mm. At first, the YIG substrate was placed on chuck table. Then, the diamond blade cut the lines detected during alignment. Finally, the workpiece rotating at high speed was washed with water and dried with air.

The surface image of the 50 μm-deep YIG grating with a width of 180 mm and a spacing of 20 mm is shown in Fig. 1. Though the grating was mechanically prepared by using thedicing saw, the periodicity and linearity were controlled well. The YIG gratings with such deep grooves are the first successful examples. Fig. 2 shows the scanning probe microscope image of an apodized YIG grating, in which the groove depth was changed from 2.0 μm to 3.0 μm at 100 nm intervals. The taper edge and the round landing were observed in each groove. However, nano-order modulation was realized in the grating depth as designed. Very recently, we found that this unique structure was effective to solve a serious problem in the propagation characteristics of the microwave YIG filters [3].

There are some know-how to reduce the structural damages caused during the dicing process. Namely, the appropriate diamond content in the blades was more than 45%. The desirable diameter of the diamond grits was less than 5 mm. The rotation speed of the blade was advisable to be about 30,000 RPM. The precise YIG gratings were prepared under these optimum conditions.

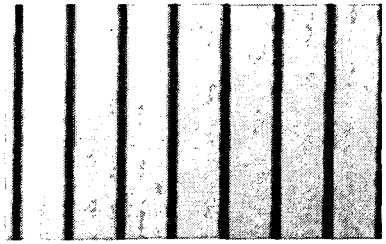

Fig. 1. Surface image of normal YIG grating.

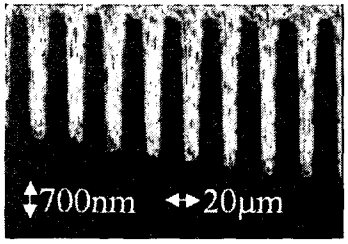

Fig. 2. Cross section image of apodized YIG grating.

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BB08

Enhanced Exchange Splitting in Co/W(001)

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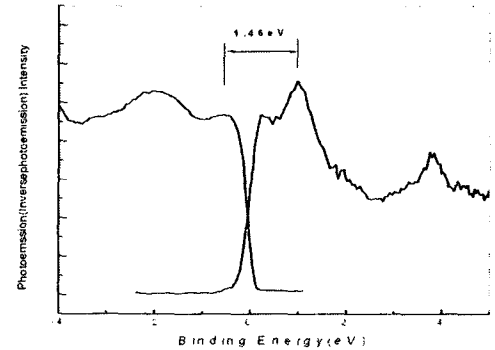
Magnetic films exhibit interesting changes in the magnetic properties when their thickness is reduced to a few atomic layers.[1] This behaviour is dominated by two opposing trends at surfaces and interfaces. An expanded atomic volume at surfaces enhances magnetism by driving it towards the atomic limit, where Hund's rule predicts maximum spin alignment. On the other hand, hybridization with a non-magnetic material at an interface suppresses magnetism. In order to minimize the interface hybridization effect and maximize the surface enhancement, noble metal substrates have been used extensively for thin magnetic overlayers. Going beyond these simpler cases we have chosen a very reactive substrate, i.e. the open W(100) surface, to show the effect of interface hybridization competing with that of surface dilution.



We have used inverse photoemission and photoemission to study the electronic states of Co and Fe on W(100) in the monolayer regime. A c(22) structure is found for Co thatexhibits a sharp minority spin state at 1.0 eV above the Fermi level, resulting in an enhanced exchange splitting when combined with data from occupied states, which is shown in above figure. The structure of Co on W(100) appears to be similar to that of c(22) Cu on W(100), where a surface alloy is formed with Cu substituting in W surface vacancies. We have also used scanning tunnelling microscopy to solve the controversial issue of the atomic structure of this c(2x2) phase. The enhanced magnetism of Co on W(100) can be explained by an expanded atomic volume in analogy with the enhanced magnetism of the c(2x2) Mn surface alloy on Cu(100) and Ni(100). Fe on W(100) does not form a c(22) structure and exhibits a much broader density of unoccupied 3d states than Co. This is indicative of stronger hybridization with W, which quenches magnetism. Comparison with a LDA calculation of layer-resolved density of states has been made.

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