## **Supporting Information**

## Enhanced secondary electron emission in nano-scale thin metal containing MgO film; Laser irradiation on creation of F centers

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**Figure S1.** Change of core-level spectra before and after laser annealing for the sample structure with MgO(1 nm)/Cr(10 nm)/MgO(50 nm) on Si substrate; (a) before laser annealing and (b) after laser annealing. To acquire Cr core level information after laser annealing, capping MgO thickness was set to 1 nm. The Mg 2p and O 1s peaks are deconvoluted with MgO, CrO<sub>x</sub> and Mg(OH)<sub>2</sub> related peaks due to rapid adsorption of water molecules on MgO surfaces. After laser annealing, adsorbed water molecules slightly decreased and the intensity of CrO<sub>x</sub> increased due to reaction between Cr interlayer and MgO matrix. Considering intensity ratio between Mg and O of MgO related peaks, laser annealing due to reaction of oxygen. This means that oxygen vacancies are formed by laser annealing. The intensity of Cr oxide shoulder increased after laser annealing. There results show critical evidence of the interaction between MgO and Cr layer during laser annealing. The weak shoulder peak of Cr oxide before laser annealing was come from the reaction between residual oxygen partial pressure of chamber and Cr layer during deposition.



**Figure S2.** For the detail information about the reaction between MgO and Cr interlayer, STEM/EDS mapping was fulfilled. The HAADF-STEM images of sample structure with MgO(200 n)/Cr(50 n)/MgO(200 n) on Si substrate; (a) before and (b) after laser annealing. The bright contrast indicated the presence of elements with higher atomic numbers; Cr element. While Cr and Mg had abrupt interface before laser annealing, Cr and Mg had blur interface after laser annealing, which indicated that Cr could react with MgO layer by laser annealing.



**Figure S3.** The cross-sectional TEM images and EDS line spectrum obtained from the simple sample structure with MgO(15n)/Cr(5n)/MgO(50n) on Si substrate; (a) before laser annealing and (b) after laser annealing. The EDS line spectrum started from the bulk MgO to the surface MgO. In the EDS line spectrum, the shallow depth of Cr layer from surface clearly interacted with MgO layer by laser annealing and cause the layer intermixing.

