Multi-physics simulation of super-resolution effect in an optical disk

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An optical disk including an active layer such as InSb indicates super-resolution effect making it possible to read out recording marks smaller than the diffraction limit [1, 2]. In order to clarify the mechanism of the super-resolution effect, multi-physics simulation of light propagation and thermal conduction in the optical disk has been carried out by using a finite element analysis program [3].

In the case of low incident light power (P=1mW), the active layer (InSb) is not melted, and profile of electric field intensity below the InSb layer shows Gaussian distribution (Fig. 1a). On the other hand, incident light with higher power (P=2mW) induces the melting of the InSb layer, and the profile of the electric field intensity becomes narrow (Fig. 1b). This narrowing light beam can be used as an optical probe with high spatial resolution. Our calculation indicates that the narrowing profile of the electric field intensity is achieved in the range of P=1.8~2.1mW. This calculated result agrees with the corresponding experimental study [2].

The response function for the super-resolution has also been obtained by the simulation of readout signal from the disk with small pit structure (Fig. 2). This response function shows a double peak structure, while the response function for normal state (non-super-resolution) shows a simple Gaussian profile. It is found that the response function for the super-resolution has high frequency components in the spatial frequency spectrum, indicating high spatial resolution readout capability.

REFERENCES

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[3] See http://www.comsol.com/ for further details.

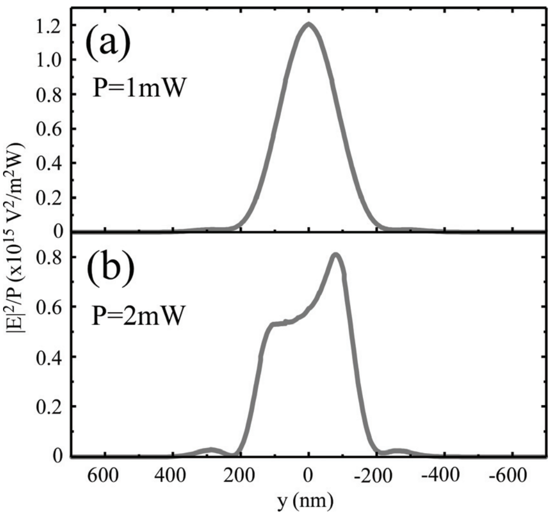

Fig. 1: Profile of electric field intensity at 15 nm below the InSb layer.

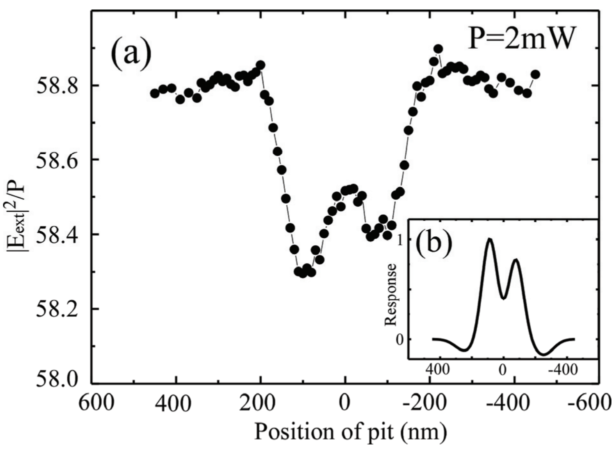

Fig. 2: (a) Readout signal from the disk with small pit structure, and (b) normalized response function.