INTISARI

Kajian Teoretis Ragam Polariton Magnetik
dalam Bahan Logam Antiferromagnet

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Telah dilakukan penelitian untuk menurunkan relasi dispersi ragam polariton magnetik dalam bahan logam antiferromagnet bergeometri semi-takhingga dan lapisan tipis. Bahan dibuat berlapis dengan bahan isolator nonmagnet agar efek penyekatan oleh elektron bebas berkurang, sehingga ragam polariton dapat dibangkitkan dengan menggunakan gelombang elektromagnet. Pendekatan teori medium effektif selanjutnya diterapkan terhadap bahan berlapis tersebut.

Kajian teoretik terlebih dahulu dilakukan untuk menurunkan perumusan relasi dispersi. Medan **B** dan **H** diturunkan dari medan **E** yang bersesuaian dengan geometri bahan menggunakan perumusan rotasi medan **E** dalam persamaan Maxwell. Subtitusi yang dilakukan untuk kedua medan ke dalam persamaan differensial gelombang serta penggunaan syarat batas dua medium menghasilkan relasi dispersi. Selanjutnya, analisis numerik dilakukan dengan menggunakan chromium (Cr) sebagai sampel bahan logam antiferromagnet.

Untuk geometri semi-takhingga, diperoleh hasil relasi dispersi ragam polariton magnetik permukaan yang bersifat *reciprocal*, $\omega(k) = \omega(-k)$, tanpa keberadaan medan magnet luar. Bila medan magnet luar diterapkan, relasi dispersi ragam polariton permukaan menunjukkan sifat *nonreciprocal*, $\omega(k) \neq \omega(-k)$. Variasi medan magnet luar yang dilakukan menunjukkan kecenderungan semakin besarnya resiprokalitas seiring bertambahnya medan magnet yang diterapkan.

Untuk geometri lapisan tipis, relasi dispersi menunjukkan bahwa frekuensi tidak bergantung arah rambat gelombang, $\omega(k) = \omega(-k)$, meskipun diterapkan medan magnet luar. Variasi ketebalan menunjukkan kecenderungan terkuantisasinya ragam polariton *bulk* sementara ragam polariton permukaan bercabang menjadi dua.

Pada kedua bentuk geometri yang diteliti, konduktivitas bahan menyebabkan timbulnya redaman dalam polariton magnetik permukaan sehingga timbul ragam bocor (*leaky mode*) dan efek *backbending*. Redaman cenderung semakin besar seiring dengan bertambahnya medan yang diterapkan. Terbukti pula bahwa spektroskopi *attenuated total reflection* (ATR) yang diperoleh bersesuaian dengan relasi dispersi dalam sistem yang terkait.

ABSTRACT

Theoretical Studies of Magnetic Polariton Modes
in Metallic Antiferromagnet Materials

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The purpose of this research is to derive the dispersion relations for magnetic polaritons in antiferromagnetic materials which are metallic. Two kinds of geometry are used. The first kind is for semi-infinite materials and the other is for thin films. By fabricating grooved structures, the free electron motion in metallic materials is limited and the screening effect is significantly reduced so that the polaritons can be excited. The calculation is primarily carried out within effective-medium theory.

The derivation of the dispersion relation is examined by firtly choosing electric fields (**E**) suitable for the geometry of materials. Associated **B** fields and **H** fields are then found using Maxwell's equations. Substitution of **B** fields and **H** fields into the wave differential equation and application of boundary conditions will lead to the dispersion relations. In the next step, the dispersion relations are solved numerically by choosing chromium (Cr) as the typical sample of metallic antiferromagnet materials.

Without external magnetic field $\mathbf{H_0}$,the dispersion relations of surface polariton modes for semi-infinite material are reciprocal, $\omega(k) = \omega(-k)$. If a magnetic field is then introduced to the system, the dispersion relations will be nonreciprocal with $\omega(k) \neq \omega(-k)$. The variation of the applied magnetic field show that the higher field leads to the larger nonreciprocity.

For thin film materials, the dispersion relations of the surface polariton modes indicate that the frequency is independent from the direction of the wave propagation even though an applied magnetic field introduced to the material. The geometry of thin film results in the quantization of the bulk polariton modes. This quantization has a tendency to be less quantized along with the decreasing of the thickness of the thin film.

In both geometries, the conductivity of metallic antiferromagnet materials leads to the existence of damping in the surface polariton modes producing leaky surface modes and backbending effect. The damping become larger when applied magnetic field is increased. By using attenuated total reflection (ATR), surface modes are also verified its spectra, which is in agreement with the related dispersion relations.