JURNAL FIZIK MALAYSIA VOLUME 23, NUMBERS 1 - 4 2002

Second harmonic generation of a uniaxial antiferromagnetic film

Siew-Choo Lim
School of Physics, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia

(Received 16 September 2001)

The second harmonic generation (SHG) of a uniaxial antiferromagnetic film based on antiferromagnetic response is calculated and analyzed by using conventional nonlinear optics approach. Within this approach, the theoretical modeling assumed weak nonlinearity and no depletion of incident waves. In the studies, in order to observe second harmonic (SH) transmission and reflection through the film, the antiferromagnetic film is configured with reference to the non-vanishing linear and second harmonic susceptibility tensor elements of the antiferromagnetic system. With these, some of the second harmonic transmissions and reflections versus frequency and thickness are calculated numerically and shown graphically.

Keywords: Antiferromagnet; nonlinear; second harmonic generation

I. INTRODUCTION

The simplest nonlinear response in a physical system subjected to incident electromagnetic radiation is second harmonic generation (SHG) [1]. In the study of nonlinear effects in dielectrics, weak nonlinear approach is usually used [1,2]. This approach has been extended to the magnetic systems and it obviously open up a simpler way to study various nonlinear effects in magnetic systems [3-5]. By using the weak nonlinear assumption, the dynamic magnetization m can be expanded in power series of the incident dynamic magnetic fields h:

$$m_i = \chi_{ij} h_{ij} + \chi i_{ijk} h_j h_k + \chi_{ijkl} h_j h_k h_l + \ldots \qquad (1)$$

With this, the complete linear and nonlinear susceptibility tensors up to third order effects for a uniaxial antiferromagnet have been calculated and analyzed subjected to single frequency incident electromagnetic waves [5].

II. FORMALISM

The non-vanishing linear and second harmonic susceptibility tensor elements of an antiferromagnet are used to determine the suitable model for the observation of second harmonic effects. From our previous calculations, the independent non-vanishing linear and nonlinear elements up to second harmonic effects in Cartesian system, (xyz), are χ_{xx}, χ_{xy}, χ_{yx}, χ_{yy}, χ_{xxz}, χ_{xyz}, χ_{yxz}, χ_{yyz}, χ_{zxx} and χ_{zyy}. The full mathematical expressions of the elements are given in our previous paper [5].

Based on these non-vanishing elements, the practical model is the antiferromagnetic film in the configuration of Voigt geometry as shown in Fig.1.

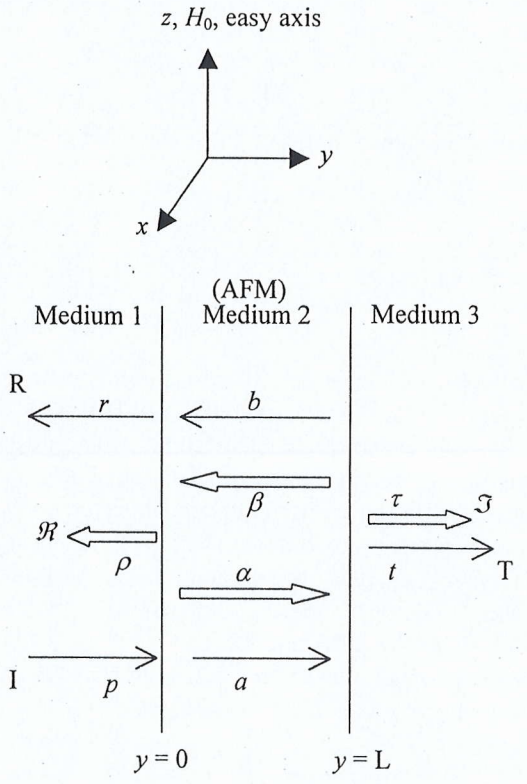

FIG. 1. Antiferromagnetic film in Voigt geometry.

Here we set y as the direction of incident waves, I, and the rf H fields in I are x-polarized. All these configurations will determine which elements should be taken into account due to the transverse nature of