ABSTRACT

DETECTION OF IRON-OXIDE SUPERPARAMAGNETIC NANOPARTICLES USING GIANT MAGNETORESITANCE (GMR) SENSORS BASED ON Co/Cu THIN FILM MULTILAYERS WITH FOUR POINT PROBE SYSTEM METHOD

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This research was carried out the detection of superparamagnetic nanoparticles iron-oxide (SPIONs) based on Co/Cu thin film multilayers GMR sensors using Standard Four Point Probe Methods (SFPPM). $[Co(1,5nm)/Cu(x)]_{20}$ thin film multilayers fabricated using DC magnetron sputtering method with variation of the Cu-layer thickness (x = 0.8, 0.9, 1.0, 1.1 and 1.2 nm). The result of measurement MR percentage by applied an external magnetic field ± 600 Gauss parallel to the sample, initially increased monotonically with the increase in the thickness of the Cu layer until it reaches the maximum value at the thickness of about 1nm and further decreased. The MR percentage was about 4.49%, 7.41%, 17.43%, 13.03% and 10.25% respectively. The present of MR phenomenon make sensors GMR potentially for detection of magnetic nanoparticles applications. The SPIONs to be detected were synthesized via coprecipitation method. Characterization using X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM) and Vibrating Sample Magnetometer (VSM) exhibiting that SPIONs well crystallized and grow in their inverse spinel structures, highly uniform morphology with grain size 12.940 ± 0,3nm and M-H loop characteristics exhibiting soft magnetic behaviour with saturation magnetization (Ms), remanent magnetization (Mr) and coercivity (Hc) is 77.164 emu/g, 7.682 emu/g and 0.0486 kOe respectively. Detection of SPIONs were dispersed in ethanol and prepared with different concentration (0.1 mg/ml, 1 mg/mL, 10 mg /ml and 100 mg/ml), were conducted using GMR sensor based on thin film $[Co\ (1,5nm/Cu(x)]_{20}$ multilayers (x = 0,9 and 1.0 nm) at room temperature. The resistance deviations of thin film after coated nanoparticles showed that the GMR sensors based on Co/Cu multilayer successfully to detect the presence of nanoparticles. The response signal from resistance deviations GMR sensors based on thin film $[Co(1,5nm)/Cu(x)]_{20}$ multilayers (x = 0.9, and 1.0 nm) exhibits log-linear function of concentration SPIONs. These results indicate that GMR sensors based on Co/Cu multilayer combined with SPIONs has potential to be used in the biosensor applications.

Keywords: Giant magnetoresistance (GMR), magnetic sensors, superparamagnetic iron-oxide nanoparticles (SPIONs)

INTISARI

DETEKSI NANOPARTIKEL SUPERPARAMAGNETIK Fe_3O_4 DENGAN SENSOR *GIANT MAGNETORESITANCE* (GMR) BERBASIS LAPISAN TIPIS Co/Cu MULTILAYER DENGAN METODE *FOUR POINT PROBE SYSTEM*

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Pada peneletian ini telah dilakukan deteksi nanopartikel superparamagnetik Fe_3O_4 berbasis sensor GMR lapisan tipis Co/Cu multilayer menggunakan *Standard Four Point Probe Method* (SFPPM). Lapisan tipis $[Co(1,5nm)/Cu(x)]_{20}$ multilayer dipabrikasi menggunakan metode DC *magnetron sputtering* dengan variasi ketebalan lapisan non magnetik Cu (x = 0,8, 0,9, 1,0, 1,1 dan 1,2 nm). Hasil pengukuran %MR dengan cara memberikan medan magnet eksternal sebesar $\pm$ 600 Gauss yang paralel terhadap sampel, awalnya mengalami peningkatan seiring dengan peningkatan ketebalan lapisan Cu hingga mencapai nilai maksimum pada ketebalan 1nm dan selanjutnya mengalami penurunan. Nilai %MR yang terukur masing-masing sebesar 4,49 %, 7,41%, 17,43%, 13,03% dan 10,25%. Fenomena MR yang terukur memberikan peluang dalam aplikasi deteksi nanopartikel magnetik. Nanopartikel Fe_3O_4 yang akan dideteksi disintesis dengan metode kopresipitasi. Karakterisasi menggunakan *X-Ray Diffraction* (*XRD), Transmission Electron Microscopy* (TEM) dan *Vibrating Sample Magnetometer* (VSM) menunjukkan bahwa nanopartikel Fe_3O_4 memiliki struktur kristal invers spinel dengan derajat kristalinitas yang tinggi, morpologi yang relatif homogen dengan ukuran butir 12,940 ± 0,3 nm dan karakteristik kurva M-H loop yang bersifat *soft* magnetik dengan nilai magnetisasi saturasi *(Ms),* magnetisasi remanen *(Mr)* dan koersivitas *(Hc)* masing-masing sebesar 77,164 emu/gram, 7,682 emu/gram dan 0,0486 kOe. Proses deteksi nanopartikel Fe_3O_4 yang dipreparasi dengan konsentrasi yang berbeda menggunakan pelarut etanol yaitu 0,1 mg/ml, 1 mg/ml, 10 mg/ml dan 100 mg/ml, dilakukan menggunakan sensor GMR berbasis lapisan tipis $[Co(1,5nm)/Cu(x)]_{20}$ multilayer (x=0, dan 1,0 nm) pada suhu ruangan. Perubahan resistansi dari lapisan tipis setelah dilapisi nanopartikel menunjukkan bahwa sensor GMR Co/Cu multilayer mampu mendeteksi keberadaan nanopartikel. Respon signal berupa perubahan resistansi yang dihasilkan sensor magnetik GMR berbasis lapisan tipis $[Co(1,5nm)/Cu(x)]_{20}$ multilayer (x= 0,9, dan 1,0 nm) memiliki relasi yang linear dengan meningkatnya konsentrasi nanopartikel Fe_3O_4 yang dideteksi. Hasil ini menunjukkan bahwa sensor GMR berbasis lapisan tipis Co/Cu multilayer yang dikombinasikan dengan nanopartikel Fe_3O_4, sangat potensial untuk aplikasi biosensor.

Kata kunci: *Giant Magnetoresistance* (GMR), sensor magnetik, nanopartikel superparamagnetik Fe_3O_4