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A Study of RCS Reduction by Radar Absorbent Material Coating

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Abstract: Radar absorbent materials have been developed to avoid enemy radars for military usage. Recently, the general RCS reduction has been adopted as a solution of radio disturbance and antenna radio disturbance problems. We will investigate the RCS of conducting targets with radar absorbent materials coating and clarify the effect on RCS reduction.

1. Introduction

RCS reduction is important to avoid radio interference problems. We study electromagnetic scattering from conducting targets with radar absorbent material (RAM) coating and clarify the effect on RCS reduction in terms of the angle of incidence, operating frequency, and thickness of RAM.

2. Formulation

Figure 1 shows a PEC target with RAM coating. The material constant of RAM is determined to satisfy the following nonreflective condition formula[1]:

$$1 = \sqrt{\frac{\dot{\mu}_r}{\dot{\varepsilon}_r}} \tanh\left(j \frac{2\pi d}{\lambda} \sqrt{\dot{\varepsilon}_r \dot{\mu}_r} \right), \qquad (1)$$

where $\dot{\varepsilon}_r$ is a complex relative permittivity tensor and $\dot{\mu}_r$ is a complex relative permeability tensor.

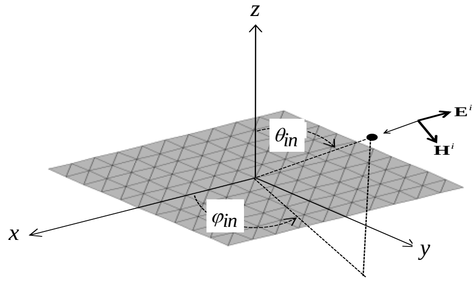
The electromagnetic scattering problems are solved by using a method based on an integral equation. Here, the matrix-vector multiplication is expedited by using the multilevel fast multiple algorithm[2]. The computational cost for the two level implementation is $O(N^{3/2})$ and it can be reduced to $O(N \log N)$ for multilevel implementation.

3. Computational Results

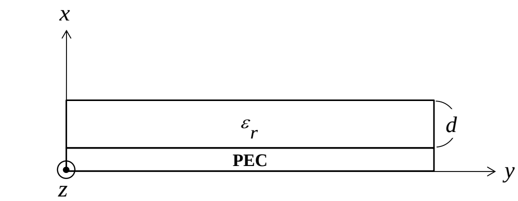
Electromagnetic scattering from a flat plate is investigated. The size of the square plate is 0.5 m × 0.5 m. The incident wave whose electric field has only x component propagates in the $-z$ direction and the amplitude is 1 V/m.

Figure 2 shows the surface current on the PEC plate when $\varepsilon_r = 1$. Here, strong current distribution is plotted by dark color. We can confirm that there are 5 dark portions on the PEC plate.

Figure 3 shows current distribution for the PEC with RAM coating. The thickness of RAM $d = 0.01$ m. The complex relative permittivity is derived by equation (1). The surface



(a) RAM coating model.



(b) Cross section of the PEC plate with RAM coating.

Figure 1. Geometry of the target.

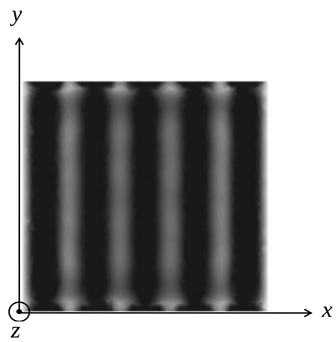


Figure 2. Surface current on the PEC.

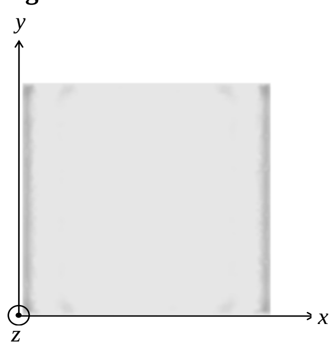


Figure 3. Surface current on the PEC with RAM coating.

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current on the PEC plate can be reduced by using RAM.

Figure 4 shows the bistatic RCSs of the conducting plate and the conducting plate with RAM coating. The incident wave impinges from $\theta_{in} = 0°$. For almost all the angles, the RCS reduction can be observed for the RAM coating case. When the observation angle is $\theta = 0°$, the RCS can be reduced to about -20 dBsm.

Figure 5 shows the value of the reflection coefficient for varying the thickness of RAM coating *d* from 0.01 mm to 0.02 mm. The value of the reflection coefficient is defined by the difference of the reflected wave at the specular angle between the PEC and the RAM coating cases[3]. When the angle of incident is $\theta_{in} = 0°$, the maximum reduction can be obtained for $d = 0.01$ mm. When $\theta_{in} = 30°$, reduction becomes about a half of that for the $\theta_{in} = 0°$ case. When $\theta_{in} = 60°$, the maximum reduction occurs for $d = 0.013$ mm.

Figure 6 shows the reflection coefficient for the fixed thickness $d = 0.01$ mm and varying the incident wavelength λ. The maximum reduction can be obtained at $\lambda = 0.1$ m for all the incident angles. For a longer wavelength, the RAM coating is not effective and the reflection coefficient converges to around zero.

4. Conclusions

We study the RCS of conducting targets with RAM coating and clarify the effect on RCS reduction in terms of the thickness of RAM. The maximum reduction -34.05 dB is obtained when the angle of incident $\theta_{in} = 0°$, the thickness $d = 0.01$ mm, and the wavelength $\lambda = 0.10$ m.

5. Reference

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[3] Y. Inazawa, I. Naito and Y. Konishi, "RCS Analysis of Absorbent Coating Scatterer by using Impedance Boundary Conditions", The Papers of Technical Meeting on Electromagnetic", IEE Japan, pp. 49-52, 2009.

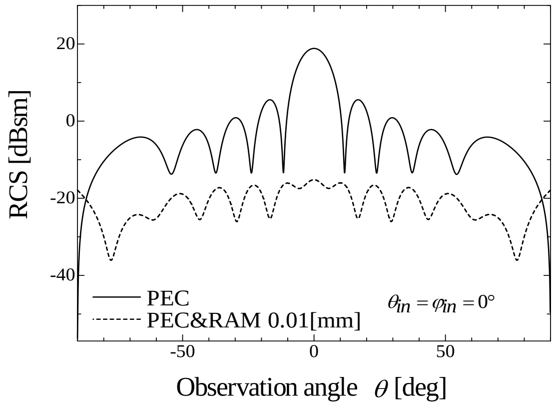

Figure 4. RCS for the PEC with RAM coating.

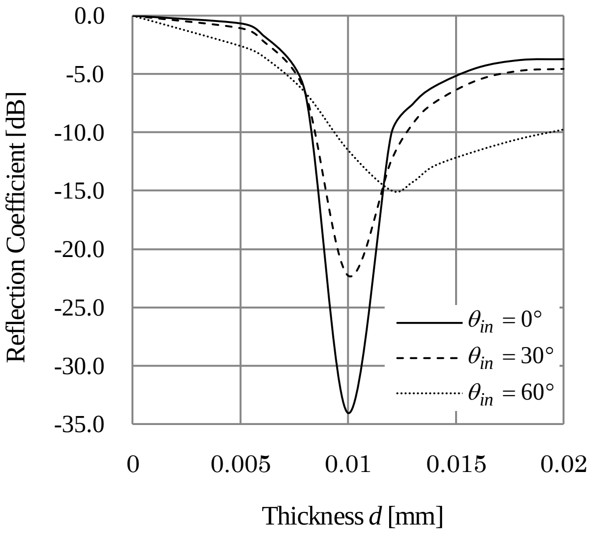

Figure 5. Reflection coefficient for varying the thickness of the RAM coating.

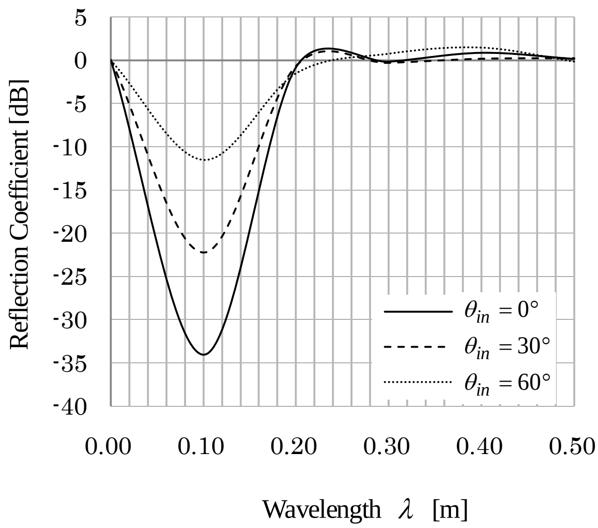

Figure 6. Reflection coefficient for varying the incident wavelength.