Parabolic antennae at telecommunication infrared wavelengths

L. S. Froufe-Pérez,
R. Paniagua-Domínguez and
J. A. Sánchez-Gil

Instituto de Estructura de la Materia (CSIC),
Serrano 121, 28006 Madrid, Spain

Luis.froufe @ iem.cfmac.csic.es

Perhaps the most important wavelength interval in the IR is spanned in the range 1260nm – 1675nm because it is used in telecommunications. Hence, developing efficient compact highly directional antennas in this regime have a potential impact in the telecommunications industry [1].

In this regard, Silicon submicron-sized particles have attracted a lot of attention in recent years [2,3]. Silicon or Germanium, among other semiconductors widely used in the microelectronics industry, present a large refractive index and low absorption in the near IR. Hence, Semiconductors are particularly suitable materials to form the basis of new nano and micro devices in the near IR.

Altough well known, Mie scattering theory [4] is somehow being rediscovered. There are several reasons for this. On the one hand, microfabrication techniques allow for a fine control on the production of massive amounts of monodisperse Si particles with prescribed dimensions [5]. On the other hand, assembly of different materials or compound micro and nano devices is also possible and relatively affordable in a conventional laboratory and, even, can be thought to be transferred to industrial production factories [6].

Appropriate combinations of different semiconductor spherical particles have been recently proven to be excellent Yagi-Uda Antennas. In particular, these assemblies of particles present strong directionality in the angular scattering pattern [7]. Also, placing a single emitter between the reflector and the first director of the antenna, the radiation emission pattern can be strongly directional [8].

Following the conventional approach of tailoring well known concepts in the radiowave regime to the optical and IR one, we propose a parabolic antenna made of submicron sized silicon particles.

In this work we show that the parabolic microantenna present a strong directionality (ratio of the maximum power emitted divided by the average one) and low backward emission in a wide range of wavelengths. Actually this range covers 5 of the 6 more widely used bands in IR telecommunications.

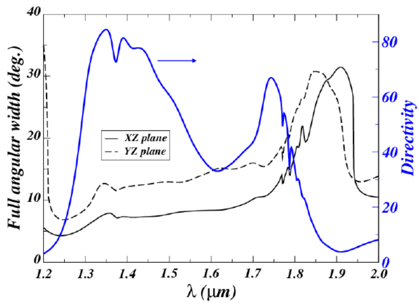

Figure 1: Full angular width and directivity of a parabolic antenna made of ~100 Si spherical particles or radius 250nm.

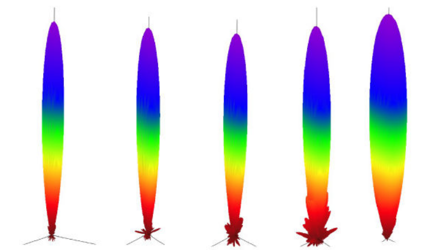

Figure 2: Emission patterns of the system emitter-antenna at different wavelengths (indicated in the legends). The emitter is a point dipole source placed at the parabola focus. The dipole points perpendicular to the emission patterns.

In figure 1 we show the spectral dependence of the directionality of the parabolic antenna (right scale), as well as the full angular width of the radiation pattern (left scale). As can be seen in this figure, the directionality varies by a factor ~2, while the angular spreading remains below 15 degrees in a wide frequency band.

In order to better illustrate this behavior, we present in fig. 2 the 3D angular spectrum of radiation for several wavelengths. It is pretty clear from these plots that the antenna behaves reasonably well in a wide band covering the telecommunications rage.

Interestingly, the angular radiation patterns are quite insensitive to the orientation of the emitter (placed at the focus of the parabola). This behavior is rather different to what is expected in other antenna configurations.

References

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