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High Gain Leaky Wave Antenna Operating at 0.566 THz

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***Abstract*—Metallic structures consisting of a central $\lambda_0/2$ slot surrounded by straight parallel wedge corrugations present high transmission enhancement for an impinging EM beam, compared to that given by a single central slot with no grooves. Here, a 0.566 THz low profile leaky-wave antenna (LWA) with triangular corrugations is numerically and experimentally analyzed. Negligible differences are observed between triangular and typical square corrugation profiles. A manufactured prototype is also numerically and experimentally studied. LWAs are of high interest in several frequency ranges, including the expanding range of the THz.**

I. Introduction

LWAs [1], [2] are characterized for achieving, despite their low profile, comparable or even higher radiation characteristics compared to larger volume antennas, as horns. In particular, very low profile LWAs can be obtained by using resonant slot on a metallic plate surrounded by corrugations At first, this radiation enhancement was associated with the Extraordinary Optical Transmission (EOT) resonance, found in the optical range [3]–[9]. As it was proved that the sole EOT plasmonic interpretation was not suitable for the microwave and millimeter range later studied [10], it was complemented by a leaky wave interpretation [1]. Based on this, several prototypes were thoroughly studied [11]–[13]. The main characteristic of the radiation mechanism for these corrugated antennas is the capability of coupling feeding power to a a leaky-wave**,** which propagates along the surface and in-phase re-radiated to the free space because of the periodicity.

With the aim of comparing the behavior arising from the utilization of different corrugation profiles, square and triangular groove profile structures operating at 0.56 THz (λ_0=536μm) were analyzed. For the triangular case, manufacturing and experimental studies were also done. Research for both antennas, along with the radiation and temporal properties of a THz Bull's-Eye antenna and how radiated pulses are shaped, were published in [14].

Designs are presented in Section I, followed by simulations in Section II and experimental results in Section III. Conclusions in Section IV provide a brief summary of the work.

II. Design

Both designs replicate the periodic straight grooves surrounding a central slot distribution discussed in [11], [12]. The input power is coupled from the input face to the output face through the central aperture, which is approximately half the operating wavelength wide and with height much smaller than the wavelength, by exciting its transversal resonance. The corrugation period is set to approximately λ_0, so as to achieve broadside radiation. The distance between the slot and the first pair of opposite grooves is such that in-phase radiation is achieved. The latter parameter, as well as the grooves' depth and width, were obtained by means of a fine optimization. A last structure with the measured dimensions of the fabricated one was also numerically analyzed, to study the differences in radiation arising from the design deviations introduced in the manufactured prototype.

III. Simulation Results

As stated in Section II, the slot width determines the transversal resonance which couples incident wave to the output interface in the form of a TM_z mode surface-wave, whereas the slot depth (or slab thickness) gives a second resonance, corresponding to the longitudinal resonance, at around $f \sim 0.8$THz. Fig. 1 shows the radiation performance as a function of angle and frequency for triangular and square corrugations designs. It can be seen that it barely differs for both cases, presenting a maximum gain of approximately 16 dB at $f \sim 0.56$ THz, +10 dB gain compared to a flat structure.

Triangular grooves structure presents, for the E-plane, a -3dB beamwidth (θ_{-3dB}) of 5.8 deg, 1 deg narrower than the square grooves case and a side lobe level of 8.6 dB, approximately 1 dB lower compared to the second case.

When designed and fabricated antennas are numerically compared, it can be seen that the latter only shows a slightly reduced directivity for almost all the band and a minor frequency shift of the maximum.

IV. Experimental Results

Transmission enhancement obtained for a flat metallic surface patterned with periodically distributed triangular grooves, inset Fig. 2, was experimentally evaluated by means of a TeraView TPS 3000 Modular Terahertz Instrument. Two experiments were carried out: input face grooves covered with copper film and uncovered grooves, so as to record the enhancement of the transmission through the slot for an impinging Gaussian beam.

As it was expected for the uncovered grooves case, transmission presented a high increment. Fig. 2 shows transmission normalized to the maximum of the uncovered case, localized at $f = 0.566$ THz.

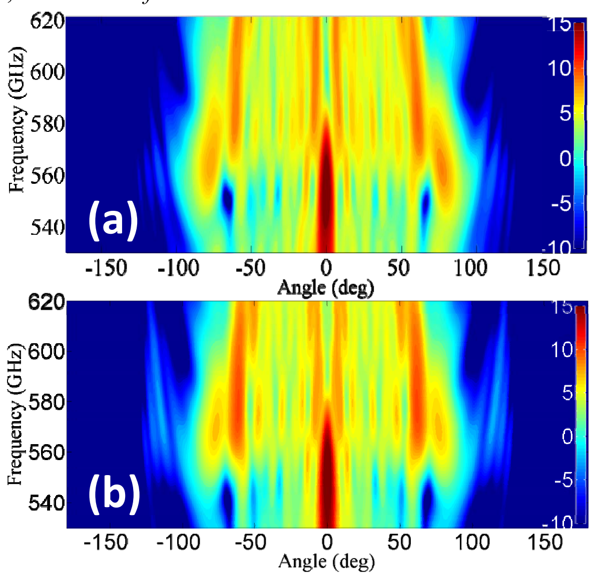

Fig. 1. Directivity as a function of angle and frequency for triangular (a) and square (b) corrugations designs.

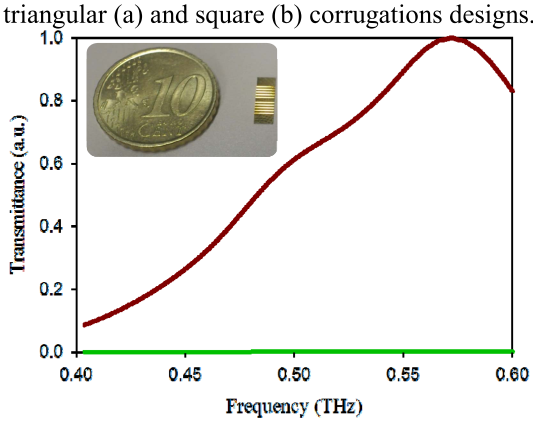

Fig. 2. Normalized transmitance for grooved (brown) and covered (green) structures. Manufactured antenna (inset).

V. CONCLUSIONS

In this work, we have numerically proved that when a slab with a central resonant slot is periodically patterned, a 10 dB gain enhancement is achievable, compared to that given by a flat slab. A directivity around 16 dB is obtained with a narrow beamwidth θ_{-3dB}= 7 deg and a side lobe level less than 10 dB, for both triangular and square corrugations structures, with negligible differences in their behavior. Experimental measurements demonstrate a large increase at 0.566 THz when corrugated and non-corrugated structures were illuminated with a THz Gaussian beam.

Due to their capability of collimating an impinging beam, enhancing thus its gain, these low profile LWAs are of high interest for the THz range, for example, for the development of quantum cascade lasers and other novel THz devices.

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