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# Diffraction grating tags structures dedicated to authentication in the THz domain

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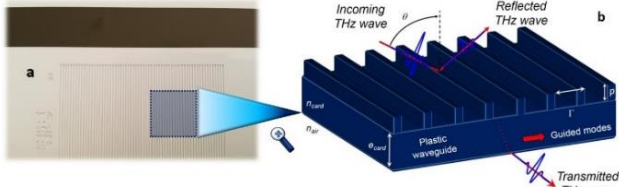
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**Abstract:** In this paper, we report on the statistical analysis of the THz signatures of identically realized diffraction grating-based tags by repeatable measurements. The correlation between the different signatures is analysed and the global error rates are evaluated from the statistical distributions and we show that error rates of 2.75% can be reached.

## INTRODUCTION

The Terahertz Identification (THID) is currently a growing research for security and anti-counterfeiting applications [1]. Recently, we demonstrated the possibility to discriminate tags structures based on a 1D diffraction grating engraved on the surface of a dielectric material by varying the geometrical parameters of the grating [2]. In this study, we focus on the statistical analysis of the THz identical tags signatures to evaluate the correlation between each other. The tag structure we propose here is schemed in Fig. 1. This structure acts as a dielectric waveguide coupled with a 1D diffractive grating which presents a unique signature in the THz domain. In this study, we realized 44 identical tags using the same protocol. Due to the randomness of the fabrication process, each tag presents tiny variations that will be used for authentication.

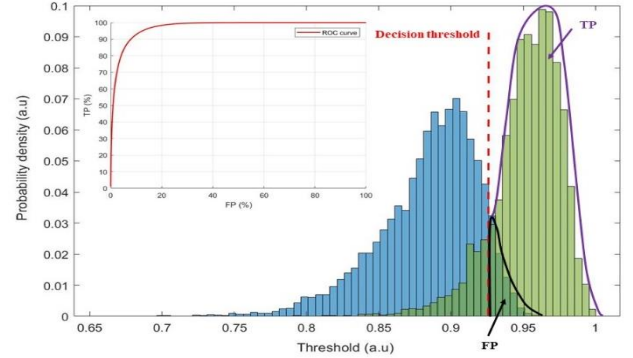


**Fig. 1.** **a**, Picture of the tag dedicated to authentication. **b**, Scheme of the proposed structure.

## STATISTICAL ANALYSIS

In order to address authentication process, we did 100 measurements of each tag at the same position. Then, we compute all the correlation coefficients combinations between measurements on the THz signatures and their 1<sup>st</sup> and 2<sup>nd</sup> derivatives which are used to highlight the fast variations (m-lines) in the signatures, and we plot the probability densities (see Fig. 2) associated to the intra-measurements (*i.e.* measurements of the same tag) and the inter-Tags, (*i.e.* measurements of a tag compared to another one). In Fig. 2, we define two parameters used for the authentication process: the True Positive (TP) and the False Positive (FP) rates. Then, we compute the ROC curve and we calculate the Equal Error Rate (EER) which are typically used in classical authentication systems comparison [3]. Finally, to evaluate the global performance of the authentication method, we also

compute the Area Under Curve (AUC), which represents the area under the ROC curve, as a more robust metric.



**Fig. 2.** Example of statistical distributions of the correlation coefficients for the Intra-Measurements (green), Inter-Tags (blue) and typical ROC curve.

Results are shown in Table 1. Error rates of 8.6% and 2.75% can be achieved using the EER and AUC, respectively, both calculated considering the 1<sup>st</sup> derivatives of the THz signatures. As a comparison, the typical EER of fingerprint authentication systems in non-optimal and exaggerated conditions are about 2% [4].

**Table 1.** Error rates calculated on signatures and their 1<sup>st</sup> and 2<sup>nd</sup> derivatives using EER and AUC metrics.

	Signatures	1 <sup>st</sup> derivatives	2 <sup>nd</sup> derivatives
EER	9.05 %	8.6 %	15.6 %
AUC	4.5 %	2.75 %	7.5 %

## CONCLUSION

In this study, we demonstrated the possibility to authenticate identical diffraction grating tags structures simply by using the tiny variations during the fabrication process. We showed that error rates of 2.75% can be reached considering the AUC metric calculated on the 1<sup>st</sup> derivatives of the THz tags signatures for authentication applications.

## ACKNOWLEDGEMENTS

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