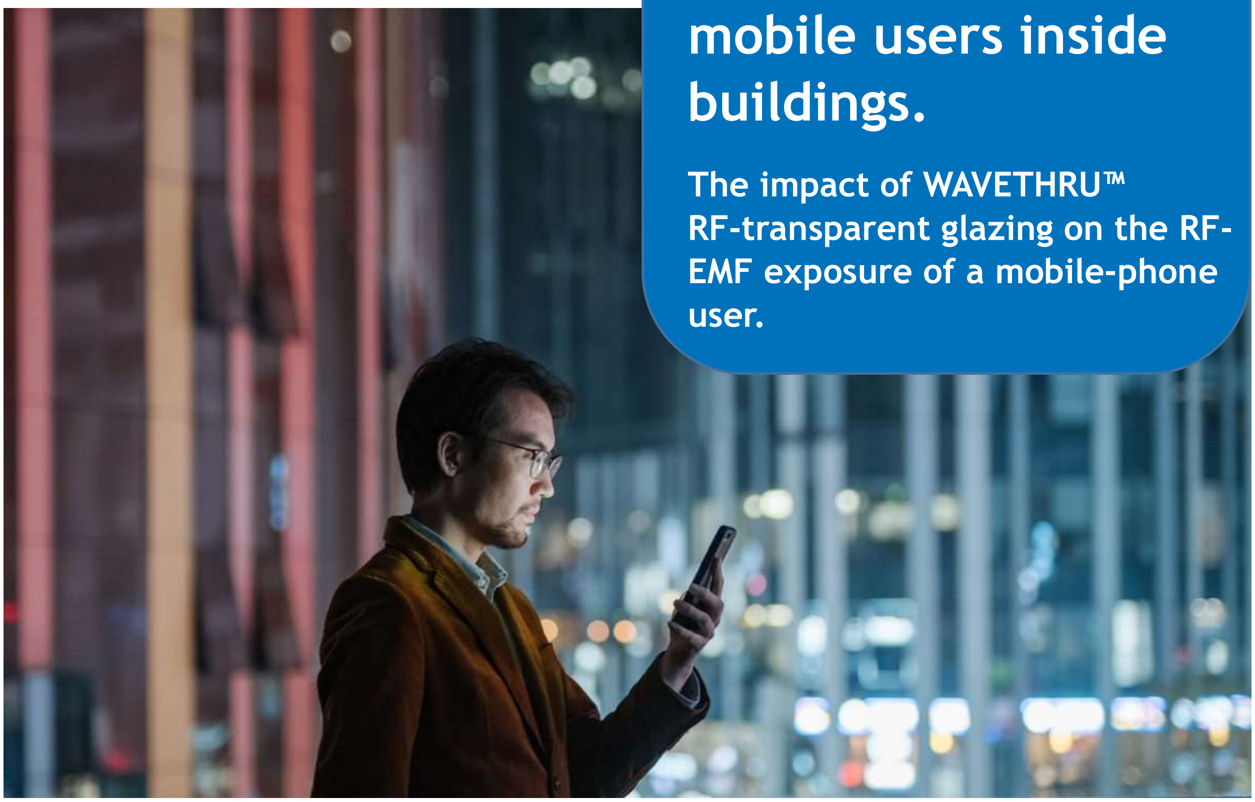
WHITE PAPER

WAVETHRU reduces the quantity of radio waves absorbed by mobile users inside buildings.

The impact of WAVETHRU™ RF-transparent glazing on the RF-EMF exposure of a mobile-phone user.



"Comparison of downlink and uplink RF exposure from telecommunications with and without WAVETHRU glass by in-situ measurements"

Study done by IMEC & Ghent University, 2019.

This study is financially supported by the European Union through FEDER-Cootech and by the Walloon region within the framework of Smartbuilding project.

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Why this study?

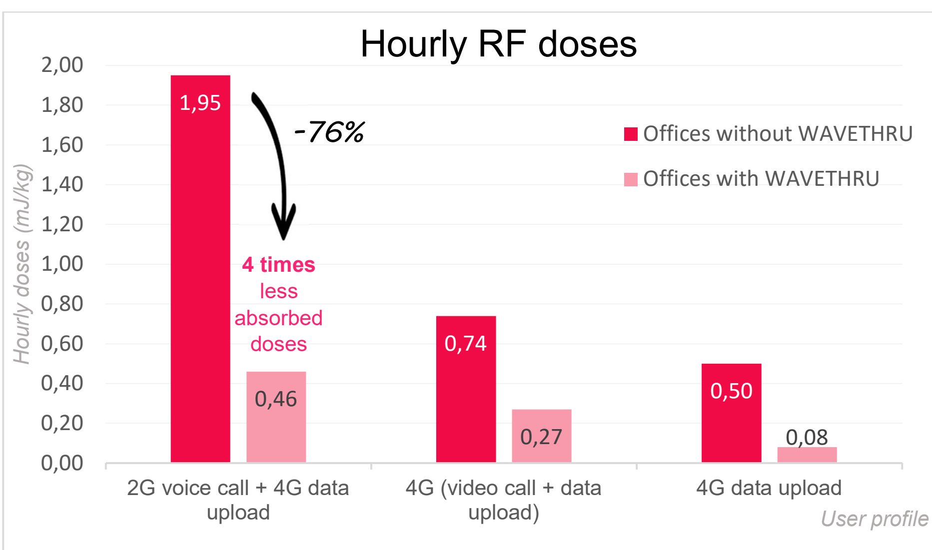
The aim of this study was to examine the impact of WaveThru on radio waves absorbed by mobile phone users inside buildings.

What is WAVETHRU?

WAVETHRU is a surface treatment applied to window that enables better transmission of radio frequencies in order to enhance and improve signal coverage inside modern buildings.

Conclusion

Thanks to WAVETHRU, more signal enters the building, resulting in improved communication between the base station and the phone. The phone puts less strain on its antenna when connecting to the base station, which means that it uses less power. Less power means less waves generated. The study shows that with WAVETHRU the phone emits one quarter of the quantity of waves, resulting in a 76% reduction in RF exposure for the typical user.



The impact of WAVETHRU™ RF-transparent glazing on the RF-EMF exposure of a mobile-phone user.

Study done by IMEC & Ghent University, 2019

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IMEC-WAVES has a large competence and a long experience in developing measurement methodologies for the assessment of RF exposure (e.g., evaluation of exposure to small cells) and their 4G (LTE) and 5G (5G-NR) measurement methods have been and will be adopted in CELENEC and IEC 62232 standards. For the measurements in this offer, CENELEC, IEC, and ECC standards as well as the Flemish measurement procedure (which is based upon the IMEC procedure), or procedures from A1-journal papers (Aerts, Joseph, Verloock, Varsier) where needed, were used.

Keywords

RF-EMF, RF-Transparent Glazing, Connectivity, Exposure, Wireless, 2G, 4G

Abstract

Coated glass found in modern buildings has a deteriorating effect on radiofrequency (RF) electromagnetic fields (EMF) used by indoor-outdoor wireless telecommunications. To improve indoor radio network connectivity AGC has developed an RF-transparent glazing solution, WAVETHRU™. **The objective of this study was to assess whether RF-transparent glazing also has a beneficiary effect on the RF-EMF exposure of an indoor mobile-phone user.** We measured both downlink (from base station to user) and uplink (from user to base station) exposure, parameters for three types of mobile usage in windowed offices with and without WAVETHRU™ glass**. An assessment and comparison of the total absorbed dose was performed for different types of users** (e.g., heavy user vs. typical user). **This way, it was shown that, through improving the indoor-outdoor wireless connectivity, WAVETHRU glazing decreased the total absorbed whole-body dose of a mobile-phone user on average by 76%**.

1. Introduction

Coated glass is ubiquitously found in modern buildings. Unfortunately, it has a deteriorating effect on radiofrequency (RF) electromagnetic fields (EMF) which are used by indoor-outdoor wireless telecommunications. To counter this, AGC is developing alternative products such as RF-transparent glazing, called WAVETHRU™.

The objective of this study was to determine the ensuing impact of WAVETHRU glazing on a person's exposure to RF-EMF in a windowed office environment versus traditional, non-RF-transparent glazing. As it was designed to increase one's indoor-to-outdoor connectivity, WAVETHRU is predicted to both decrease the power needed by a user device to transmit its signal to a base station (resulting in a lower *uplink* exposure) as well as increase the power of the base station's signal (resulting in a higher *downlink* exposure) in the room which is furnished with WAVETHRU.

However, in order to assess the impact on one's total exposure, it is essential to combine the base station's downlink and the mobile phone's uplink exposure into a single exposure proxy: the RF-EMF dose (in joule per kilogram, J/kg) absorbed by the subject. For this, the framework was used that was introduced in Ref. [1], further developed in Ref. [2] and previously applied in similar studies comparing multiple exposure scenarios in the same environment [e.g. 3,4].

2. Methods

2.1. RF-EMF exposure assessment

In order to determine the impact of WAVETHRU glazing on a user's total RF-EMF exposure, the following steps were taken: (1) *in-situ* measurements of both downlink (from base station to user) and uplink (from user to base station) exposure parameters in a number of adjacent windowed offices with and without WAVETHRU™ glass; and (2) calculation of the total absorbed RF-EMF dose (due to both uplink and downlink exposure) for different usage scenarios (e.g., heavy user vs. typical user) and comparison between the adjacent offices with and without WAVETHRU™ glass.

In the first step, the downlink and uplink exposure parameters were measured with dedicated equipment:

- A mobile phone (OnePlus 6T) with the drive test application "Azenqos", with which several parameters were logged, such as the transmit power P_T of the device.
- A Narda *Selective Radiation Meter* (SRM-3006) in combination with a tri-axial electric-field antenna, measuring the channel power density S of downlink telecommunications signals, following Ref. [5].

The details of the second step are out of the scope of this white paper but can be found in Refs.[1-4]. In short, the **RF-EMF dose is calculated by multiplying the duration the subject is exposed to a source by the RF power of that source at the subject's location and by the rate at which RF energy is absorbed by the body**. Most downlink sources are involuntary and the exposure time is equal to the scenario time. Conversely, in this study the uplink sources are assumed to be controlled by the subject (*other people's mobile devices are not taken into account*), and the exposure time depends on the specific use (t_{use}). Finally, the contributions of all the considered sources are added to obtain the subject's total RF-EMF exposure.

2.3 Exposure scenarios

Different exposure scenarios were assessed, with varying mobile phone-use time t_{use} and for varying purposes: calling (voice or video) or data use. In this study, 2G GSM (Global System for Mobile Communications) was used for the voice call and 4G LTE (Long Term Evolution) for the video call and data upload. Besides 'non-user', three more user profiles were assigned to the subject – heavy, medium, and light – with data upload volumes between roughly 300 kB and 1500 kB per hour during daytime and voice/video call times of 2–86 s per hour during daytime (Table 1).

Table 1

User	Upload volume[1,2] [MB]	Call time[1,3] [s]
Non-user	0	0
Heavy	1.542	86
Medium	0.580	12
Light	0.298	2

[1] per hour during daytime

[2] t_{use} [s] = data upload volume [Mb] x throughput [Mbps]

[2] t_{use} [s] = call time [s]

Furthermore, in addition to the 'traditional' user type (2G voice call + 4G data upload), a 'mobile-data only' user type (4G video call + 4G data upload) and a 'non-caller' user type (only 4G data upload) were defined (Table 3). Hence, in total, nine user profile–type combinations were considered (besides non-user).

2.4. Area

This study was carried out in in an office building in Gosselies, Belgium in a corridor with ten adjacent windowed offices. Three of the offices were furnished with WAVETHRU glass, the other seven were furnished with low-emissivity (low E) coated glass. On the opposite side of the corridor, towards the inner part of the building, three non-windowed meeting rooms were situated. Besides these 13 rooms, measurements were also carried out along the corridor, and in the entrance hallway.

3. Results & Discussion

3.1. Connectivity

During the 2G voice call as well as both of the 4G scenarios, four of the five or six highest P_T (and correspondingly, lowest S) were measured in the offices without WAVETHRU. On average, P_T was 36–75% lower in offices with WAVETHRU compared to offices without and not adjacent to an office with WAVETHRU, while S was 12 to 18 times higher.

Furthermore, comparing the 4G to the 2G connectivity, S was generally higher (0.50 μW/m^2 vs. 0.11 μW/m^2) and P_T lower (32 mW vs. 480 mW).

It should be noted that during the 4G file upload, the difference in P_T was less pronounced than during the two other scenarios. Indeed, whereas P_T was generally lower during a 4G file upload than during a 4G video call, P_T in the offices with WAVETHRU was actually higher. However, this makes sense as a faster transmission of data may also require a higher transmit power (i.e. the transmission of more energy in a shorter time), and on average, the throughput was about 4 times higher in offices with WAVETHRU. **In fact, only in two offices was the average throughput higher than 10 Mbps and both had WAVETHRU glazing**.

Table 2

User	Average hourly D_{wb} in offices with low-E coated glass [mJ/kg]		
Non-user	0.003		
	Traditional	*Mobile-data only*	*Non-caller*
Light user	1.98	0.73	0.49
Medium user	12.48	2.56	0.95
Heavy user	75.62	14.38	2.51

Table 3

User	Average hourly D_{wb} in offices with WAVETHRU glazing [mJ/kg]		
Non-user	0.003		
	Traditional	*Mobile-data only*	*Non-caller*
Light user	0.48	0.20	0.10
Medium user	2.89	0.83	0.16
Heavy user	18.87	5.30	0.37

3.2. Exposure

Hourly RF doses were calculated for all user profile–type combinations in offices with low-E coated glass (Table 2) and WAVETHRU glazing (Table 3).

Due to a stronger base station connectivity, **the total exposure of a non-user is the highest in the offices with WAVETHRU glass** (and those adjacent to offices with WAVETHRU) because of the increased downlink exposure and the lack of uplink exposure. In this case, the relative increase in exposure between offices with WAVETHRU glass and offices with low-E coated glass is on average 1200%.

However, the absolute dose for a non-user remains (very) low compared to any one of the user scenarios (Tables 2 and 3). Indeed, **because uplink is the dominating source of exposure in the considered usage scenarios, even for a light non-caller user, WAVETHRU glazing has a beneficial impact on the total exposure** (reduction of 63–85%), since it *significantly* decreases the transmit power required by the user device for the signal to reach the base station.

It should be noted that due to the combined effect of lower transmit powers and higher throughputs, the largest relative exposure reduction (80-85% with WAVETHRU) is found for the mobile upload-only non-caller user.

4. Conclusions

Compared to low-emissivity coated glazing ubiquitously found in modern passive buildings, **WAVETHRU™ RF-transparent glazing clearly improved the indoor-outdoor radio connection for both 2G and 4G**, with higher received powers of the base station signals (downlink) and lower transmit powers of the user device (uplink), as well as higher throughputs. ***Moreover, the combined effects of the improved connection was also highly beneficial for a mobile-phone user's RF exposure*. On average (considering all user scenarios), WAVETHRU glazing decreased the total absorbed whole-body dose of a user by 76%.**

References

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