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# X-RAY IMAGE DEGRADATION PASSING THROUGH THIN GLASS SUBSTRATE

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**Abstract.** *The degradation of X-ray image passing through thin glass substrate was experimentally investigated in term of modulation transfer function (MTF). The screen was prepared by sedimentation of the powder phosphor ($Gd_2O_2S$:Eu) on thin glass substrate with thickness 140 μm (Waldemar Knittel- GmbH). The experiment was carried out under X-ray mammographic conditions. The beam quality was 28 kV, 60 mAs, with W/Rh target/filter combination. The screen was coupled to an optical readout device including a CMOS remote RadEye HR photodiode pixel array. Results showed that there is a 40% degradation of the MTF on average, in the whole spatial frequency range, due to the glass substrate. The glass substrate has a low impact on resolution of the image at low frequencies (12% on average, up to 2.7 cy/mm) and a high impact at medium and high frequencies (70% on average).*

## 1 INTRODUCTION

Scintillation materials used in medical imaging applications usually are deposited on one side of a thin glass substrate. The transfer of an image through this substrate results in a loss of resolution and contrast.[1] This problem occurs in X-ray image intensifiers (conventional radiography)[2] and in crystalline Silicon (Si) optical detectors such as CCDs and CMOS sensors (digital radiography), where direct deposition of the phosphor on the surface of the photodetectors is not indicated.[3]
Modulation transfer function (MTF) of the glass substrate has been previously studied in general cases.[1]-[3] In the present work the degradation of an X-ray image passing through a thin glass substrate was experimentally investigated in term of MTF.

## 2 MATERIALS AND METHODS

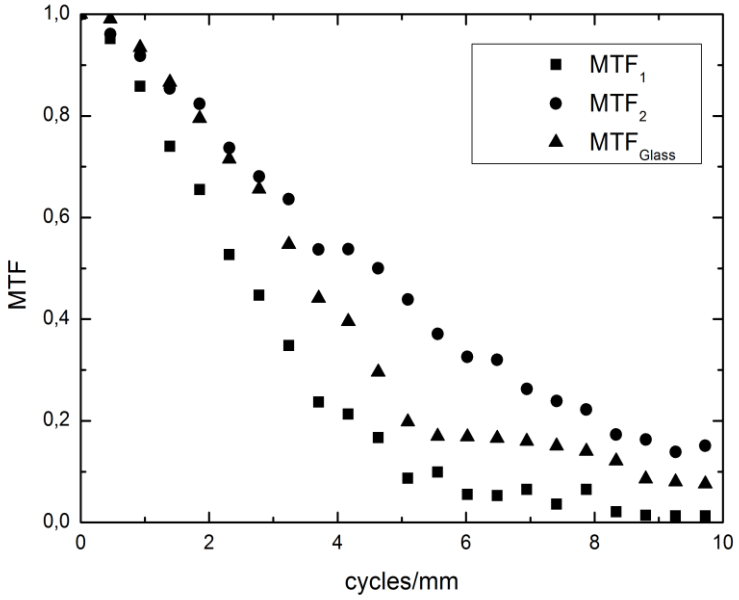
The phosphor was used in the form of thin layers (test screens) to simulate the intensifying screen employed in X-ray mammography. The screen was prepared by sedimentation of the powder phosphor ($Gd_2O_2S$:Eu) on thin glass substrate with thickness 140 μm (Waldemar Knittel- GmbH). The experiment was carried out under X-ray mammographic conditions. The beam quality was 28 kV X-ray high tube voltage, 60 mAs tube current, W/Rh target/filter combination. The screen was coupled to an optical readout devise including a CMOS remote RadEye HR photodiode pixel array.[4] The CMOS photodiode array has a format of 1200x1600 pixels with a pitch of 22.5. The CMOS photodiode array consists of a N-well diffusion on p-type epitaxial silicon. The $Gd_2O_2S$:Eu screen was directly overlaid onto the active area of the CMOS (no optical coupling was used) and held by using a thin polyurethane foam layer for compression between the screen and the 1-mm-thick graphite cover.
The MTF was measured: a) with the glass substrate directly coupled to the photodiode array ($MTF_1$) and b) with the phosphor directly coupled to the photodiode array ($MTF_2$). In both cases the slanted-edge technique was used.[4] By taking into account that the MTF of an imaging system is the product of separate MTF components of an imaging system, thus the MTF of the glass substrate ($MTF_{glass}$) is:[5]

$$MTF_{glass}(u) = \frac{MTF_1(u)}{MTF_2(u)} \quad (1)$$

## 3 RESULTS AND DISCUSSION

Figure 1 shows the $MTF_1$ and the $MTF_2$ of the detector. From this figure can be depicted there is an obvious degradation of the MTF due to thin glass substrate. $MTF_1$ is 40% lower than $MTF_2$ on average, in the whole spatial frequency range. When the glass substrate is directly coupled to the photodiode array ($MTF_1$), the light photons emitted by the phosphor interact with the glass substrate leading to a subsequent degradation of the MTF. When the phosphor is directly coupled to the photodiode array ($MTF_2$) the light photons are directly detected by the photodiode array without interaction with the glass substrate. In this case there is no degradation of the MTF caused by the glass substrate. Furthermore figure 1 shows the MTF of the glass substrate ($MTF_g$) calculated by (1). The glass substrate has a low impact on resolution of the image at low frequencies (12% on average, up to 2.7 cycles/mm) and a higher impact at medium and high frequencies (70% on average).

Figure 1: Comparison of the MTFs curves for both cases. MTF of the




glass substrate also shown.

## 4 CONCLUSIONS

At the present study the impact of the thin glass substrate on the resolution of X-ray image was investigated. Results showed that there is a 40% degradation of the MTF on average, in whole spatial frequency range, due to the glass substrate. The glass substrate has a low impact on resolution of the image at low frequencies (12% on average, up to 2.7 cy/mm) and a high impact at medium and high frequencies (70% on average).

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