UNIVERSITY OF LEEDS

This is a repository copy of *Restoration of Damaged Dental Enamels using Nano-Scale Iron-Calcium Phosphate Minerals and Femto-Second Pulsed Near-IR Lasers*.

White Rose Research Online URL for this paper:
http://eprints.whiterose.ac.uk/154197/

Version: Submitted Version

Proceedings Paper:

Anastasiou, AD, Strafford, S, Edwards, TJ et al. (6 more authors) (2019) Restoration of Damaged Dental Enamels using Nano-Scale Iron-Calcium Phosphate Minerals and Femto-Second Pulsed Near-IR Lasers. In: Proceedings of the 2019 Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, CLEO/Europe-EQEC 2019. Lasers and Electro-Optics Europe (CLEO EUROPE),, 23-27 Jun 2019, Munich, Germany. IEEE . ISBN 9781728104690

https://doi.org/10.1109/CLEOE-EQEC.2019.8872675

© 2019, IEEE. Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collective works, for resale or redistribution to servers or lists, or reuse of any copyrighted component of this work in other works.

Reuse
See Attached

Takedown
If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

White Rose
university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

Restoration of Damaged Dental Enamels using Nano-scale Iron-Calcium Phosphate Minerals and Femto-second pulsed near-IR Lasers

A D Anastasiou[a], S Strafford[b], T J Edwards[d], , M Malinowski[b], C T A Brown[d], M N Routledge[c], A.P. Brown[a], M.S Duggal[b], Animesh Jha[a]

[a] *School of Chemical and Process Engineering, University of Leeds, Leeds LS2 9JT, UK*
[b] *Leeds Dental School, Worsley Building, University of Leeds, Leeds LS2 9JT, UK*
[c] *Leeds Institute of Cardiovascular and Metabolic Medicine, Faculty of Medicine and Health, University of Leeds, Leeds LS2 9JT, UK*
[d] *SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife, KY16 9SS, U.K.*
Corresponding author: a.jha@leeds.ac.uk

Need: Dental enamel is an acellular and avascular mineralised tissue, containing more than 95% calcium phosphate mineral. Although, the underlying softer dentine is connected with the microvasculature via the soft tissue and, therefore, possesses intrinsic regenerative capacity for mineralisation, the superficial enamel lacks regenerative potential. Consequently, the oral acid induced erosive damage on enamel is irreversible, and leads to lesion formation, which if unattended, may lead to hypersensitivity and feeling of pain. Advanced stage of eroded enamel with symptoms of hypersensitivity might lead to tooth loss in adults. Traditional clinical strategies for the repair of acid-eroded enamel include the use of off-shelf toothpastes and BIS-GMA polymeric materials; the latter is structurally incompatible with natural enamel due to mismatched thermal expansion coefficient and mechanical properties. As a result this type of bonding leads to failure of restored enamel area in a challenging oral environment [1]. Modern toothpastes only provide temporary symptomatic relief from hypersensitivity. Till date, no long-term or permanent solution for treating early stages of acid erosion is on offer. Associated with acid erosion is also erosive wear which affects especially the ageing population and leads to lingual tooth thinning and weakening. Rebuilding the entire damaged tissue region remains a challenge.

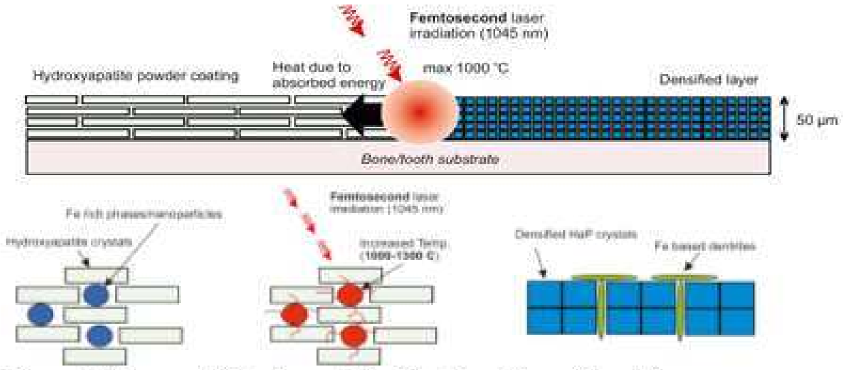

Figure 1: Process of sintering and densification of iron rich calcium phosphates after laser irradiation

Solution: In the absence of any intrinsic regenerative means of restoring damaged enamel, our investigation explains a new technique based on novel exogeneous tissue re-engineering methodology, in which the mineralisation of tooth surface involves: **i)** *application of nano- and amorphous iron-calcium phosphate minerals* (e.g. hydroxyapatite, fluorapatite and brushite[2]) in the form of colloidal paste; which is then **ii**) *bonded with the surrounding healthy enamel by irradiating with a femto-second pulsed near-IR laser*. The presence of a homogeneous dispersion of nano-scale of iron oxide in the calcium-iron phosphate matrix acts as resonant antennae for absorbing near-IR pulsed laser radiation, which helps in the dispersion of thermal energy uniformly in the irradiated region without causing damaged to the healthy tissue [3]. The two steps (i) and (ii) are illustrated in **Figure 1**. The mechanisms of mineral phase transformation and heat dissipation have been analysed for different irradiation conditions (e.g. at 1040 nm wavelength, 1 GHz repetition rate and 0.4 W average power), and the resulting structural changes are compared for understanding the bonding and potential radiation induced damage mechanisms including ablation, thermal and toxicity effects. Potential opportunity for micro-surgical device engineering is discussed for ultimate clinical use. The mechanical properties including brushing trials on restored surfaces of bovine enamels are also reported.

References:

[**1**]. J F McCabe, and AWG Wallis 2013. Applied Dental Materials, Wiley.
[**2**]. A D Anastasious et al: Materials & Design, https://doi.org/10.1016/j.msec.2017.02.116
[3]. A D Anastasious et al: Acta Bio-Materialia (2018) https://doi.org/10.1016/j.actbio.2018.02.012.

Acknowledgments: The authors acknowledge the support from the EPSRC (EP/K020234/1), Marie-Curie IAPP (LUSTRE) and Marie Curie IF (PRe-FActo) projects.