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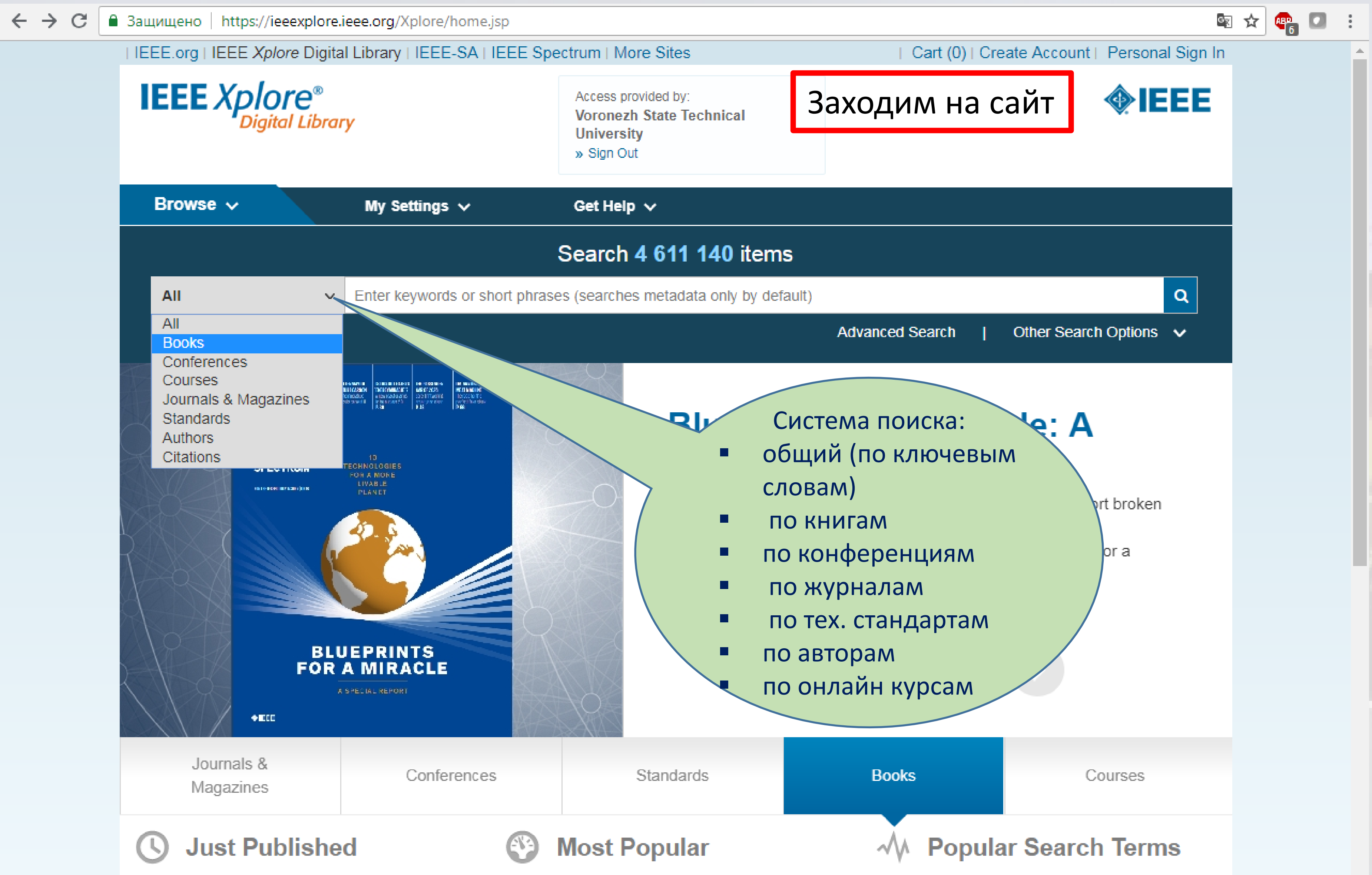

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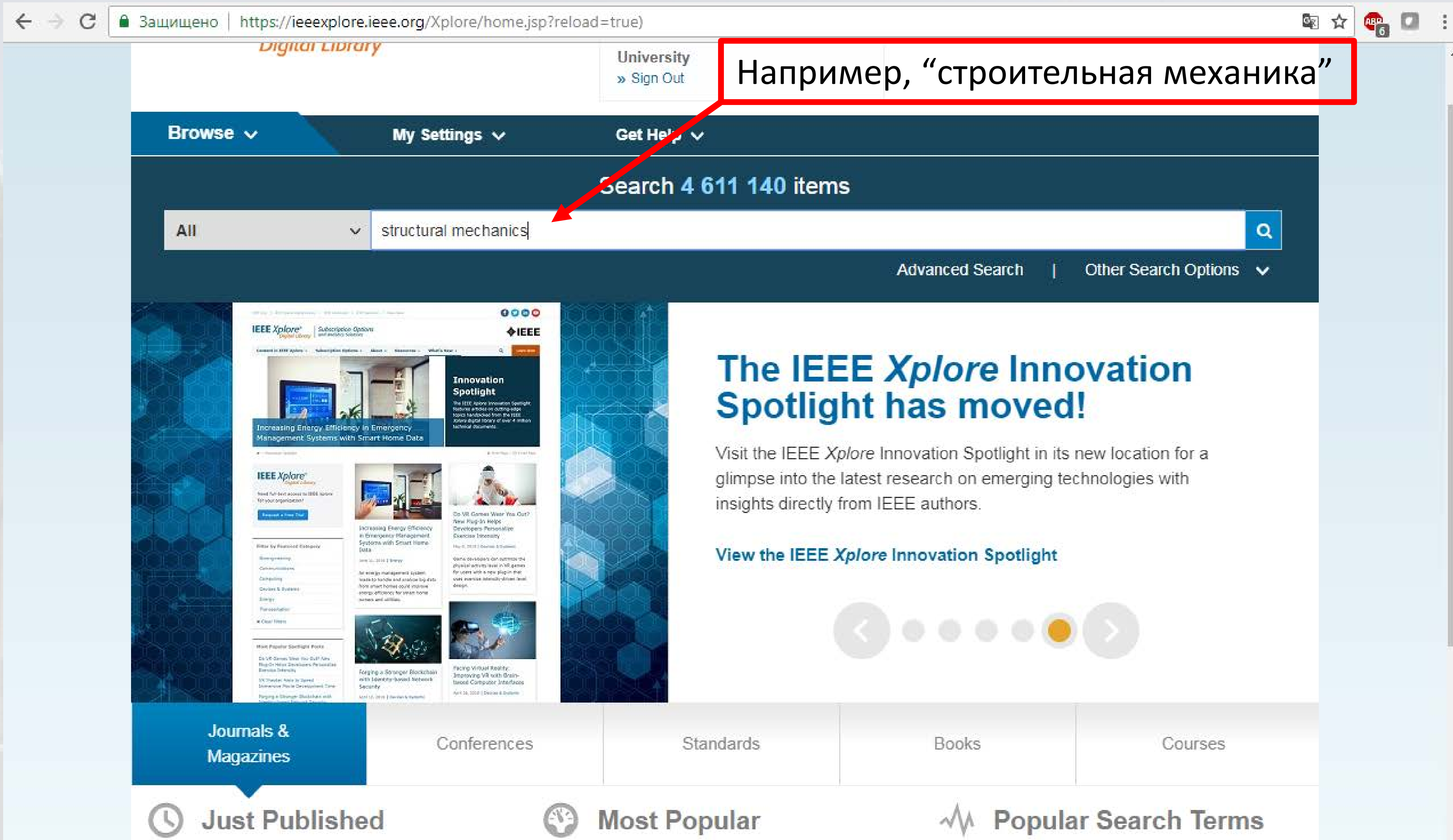

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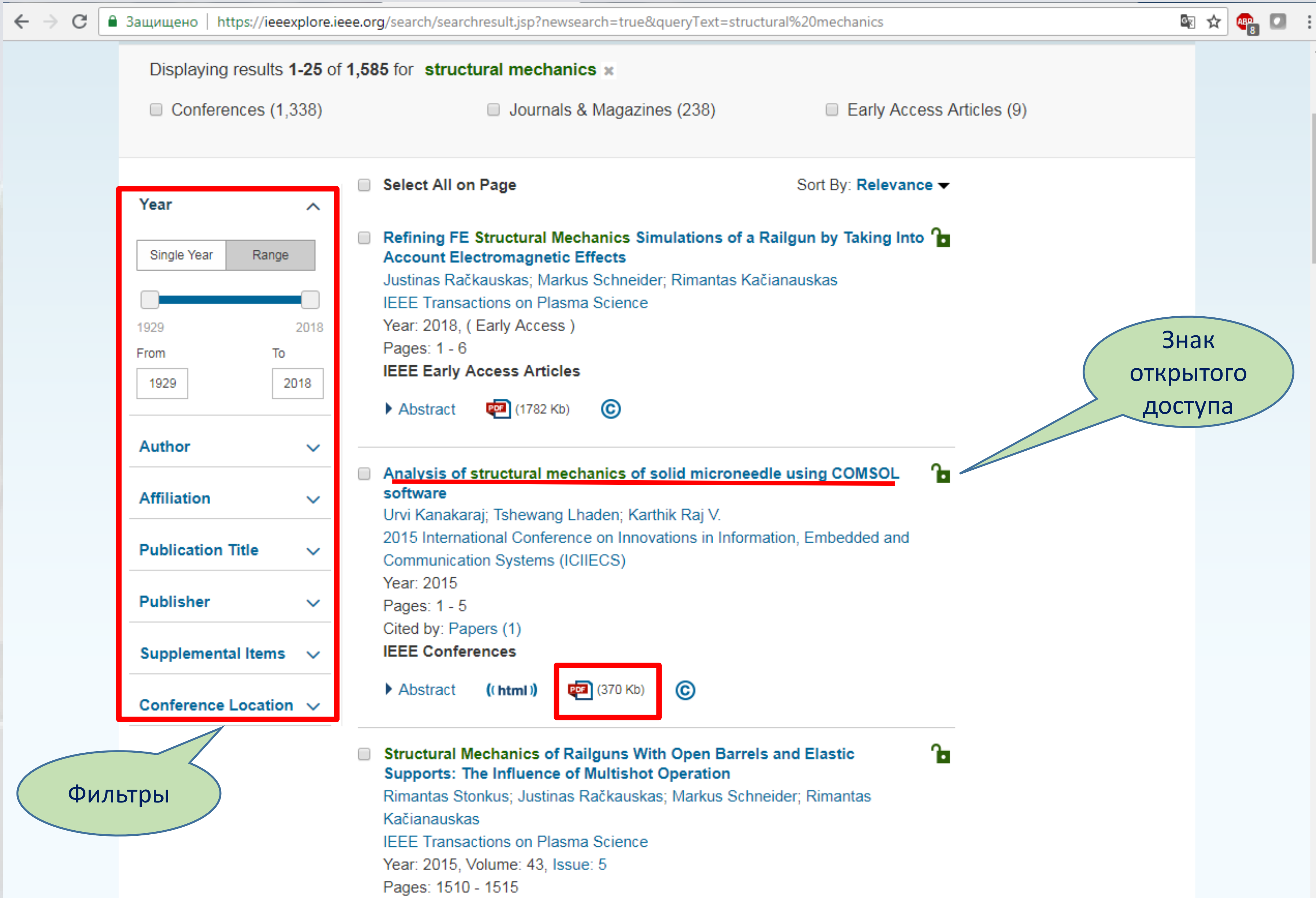

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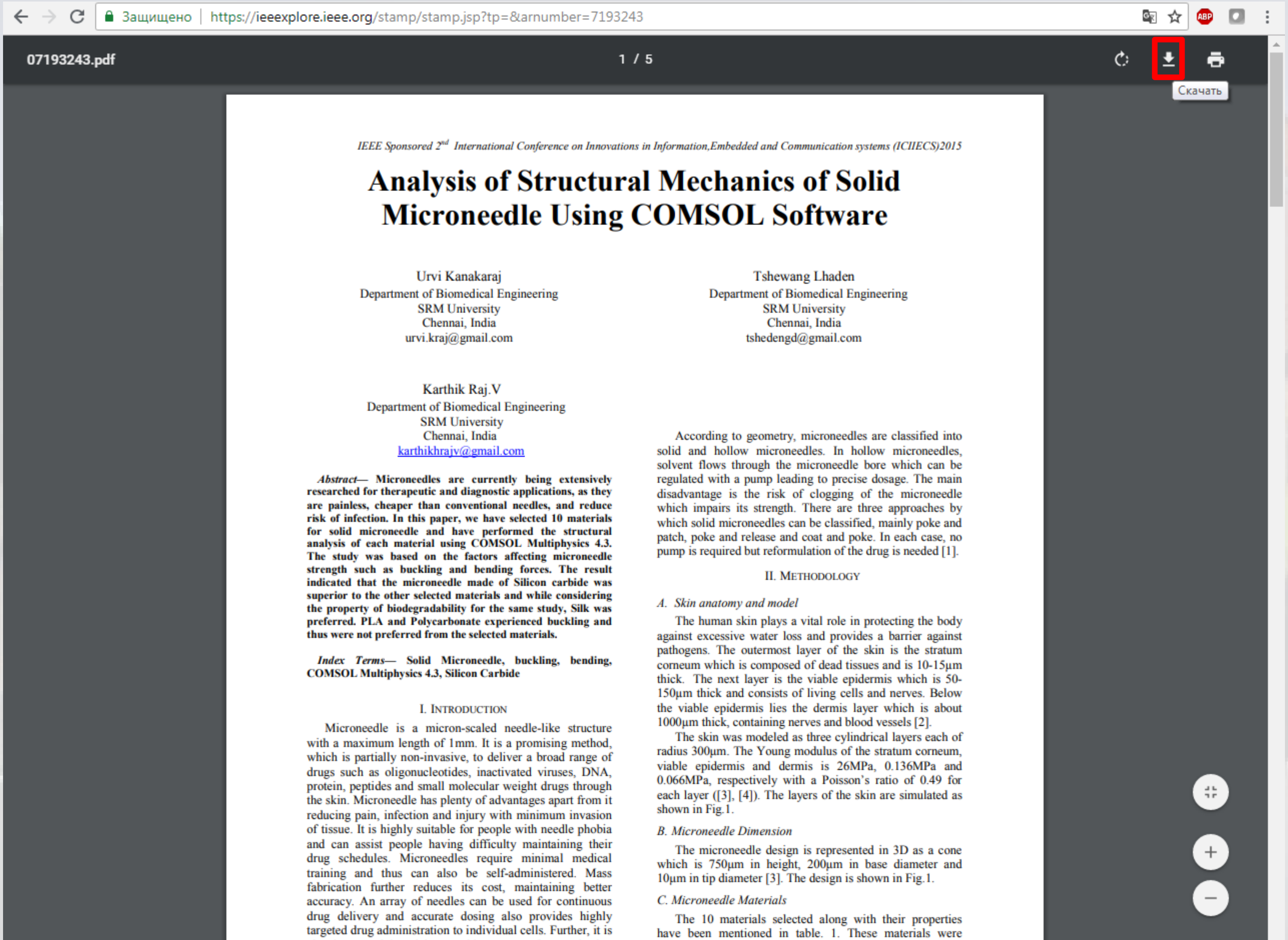

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Analysis of Structural Mechanics of Solid Microneedle Using COMSOL Software

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***Abstract*— Microneedles are currently being extensively researched for therapeutic and diagnostic applications, as they are painless, cheaper than conventional needles, and reduce risk of infection. In this paper, we have selected 10 materials for solid microneedle and have performed the structural analysis of each material using COMSOL Multiphysics 4.3. The study was based on the factors affecting microneedle strength such as buckling and bending forces. The result indicated that the microneedle made of Silicon carbide was superior to the other selected materials and while considering the property of biodegradability for the same study, Silk was preferred. PLA and Polycarbonate experienced buckling and thus were not preferred from the selected materials.**

***Index Terms*— Solid Microneedle, buckling, bending, COMSOL Multiphysics 4.3, Silicon Carbide**

I. Introduction

Microneedle is a micron-scaled needle-like structure with a maximum length of 1mm. It is a promising method, which is partially non-invasive, to deliver a broad range of drugs such as oligonucleotides, inactivated viruses, DNA, protein, peptides and small molecular weight drugs through the skin. Microneedle has plenty of advantages apart from it reducing pain, infection and injury with minimum invasion of tissue. It is highly suitable for people with needle phobia and can assist people having difficulty maintaining their drug schedules. Microneedles require minimal medical training and thus can also be self-administered. Mass fabrication further reduces its cost, maintaining better accuracy. An array of needles can be used for continuous drug delivery and accurate dosing also provides highly targeted drug administration to individual cells. Further, it is also integrated into lab-on-a-chip systems for monitoring

According to geometry, microneedles are classified into solid and hollow microneedles. In hollow microneedles, solvent flows through the microneedle bore which can be regulated with a pump leading to precise dosage. The main disadvantage is the risk of clogging of the microneedle which impairs its strength. There are three approaches by which solid microneedles can be classified, mainly poke and patch, poke and release and coat and poke. In each case, no pump is required but reformulation of the drug is needed [1].

II. Methodology

A. Skin anatomy and model

The human skin plays a vital role in protecting the body against excessive water loss and provides a barrier against pathogens. The outermost layer of the skin is the stratum corneum which is composed of dead tissues and is 10-15µm thick. The next layer is the viable epidermis which is 50-150µm thick and consists of living cells and nerves. Below the viable epidermis lies the dermis layer which is about 1000µm thick, containing nerves and blood vessels [2].

The skin was modeled as three cylindrical layers each of radius 300µm. The Young modulus of the stratum corneum, viable epidermis and dermis is 26MPa, 0.136MPa and 0.066MPa, respectively with a Poisson's ratio of 0.49 for each layer ([3], [4]). The layers of the skin are simulated as shown in Fig.1.

B. Microneedle Dimension

The microneedle design is represented in 3D as a cone which is 750µm in height, 200µm in base diameter and 10µm in tip diameter [3]. The design is shown in Fig.1.

C. Microneedle Materials

The 10 materials selected along with their properties have been mentioned in table. 1. These materials were selected because they can be classified into the three main

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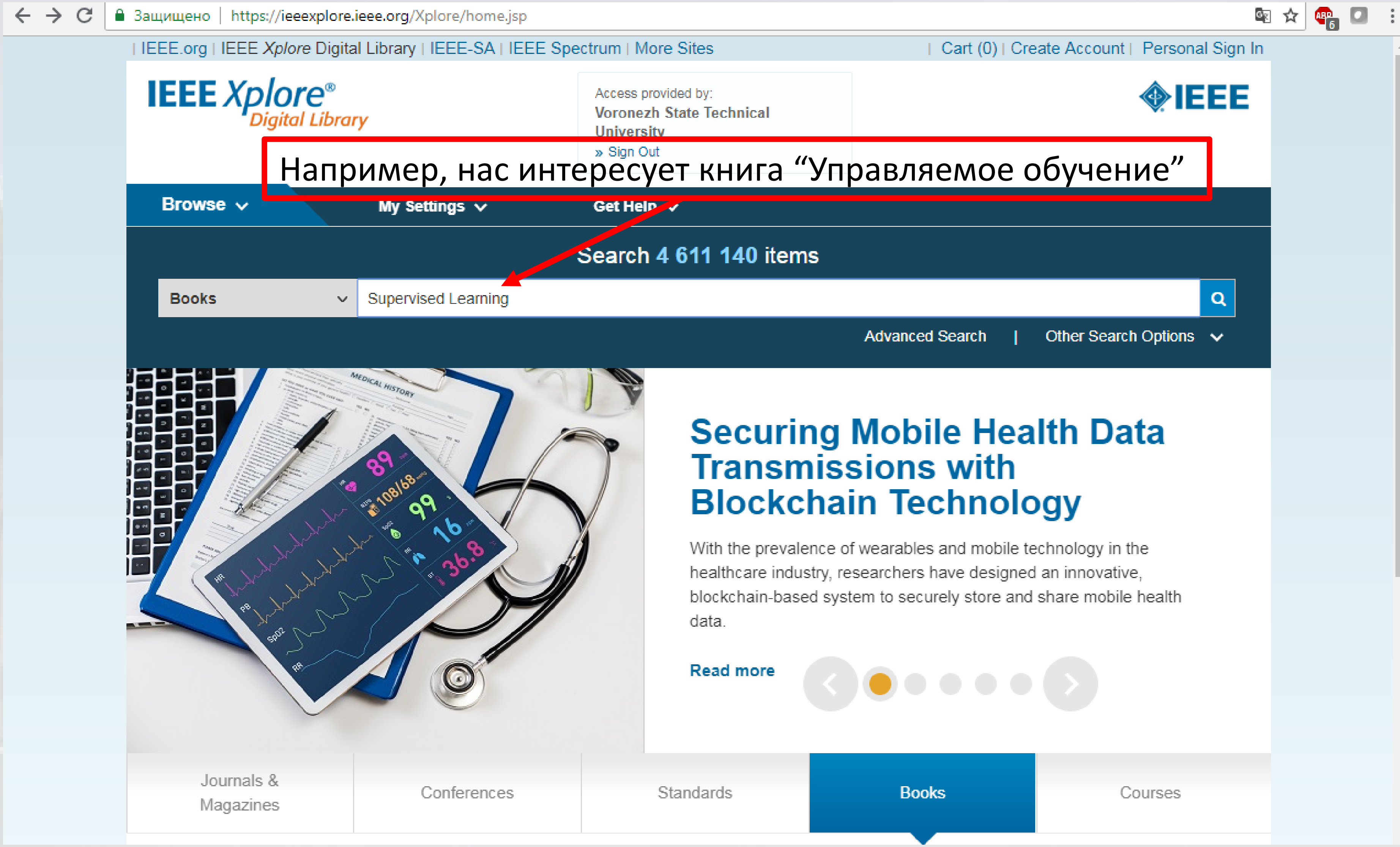

Результаты поиска