

Review

# A Pulsed Current Application to the Deformation Processing of Materials

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**Abstract:** A review of studies on the electroplastic effect on the deformation process in various conductive materials and alloys for the last decade has been carried out. Aspects, such as the mode and regimes of electric current, the practical methods of its introduction into materials with different deformation schemes, features of deformation behavior accompanied by a pulsed current of different materials, structural changes caused by the combined action of deformation and current, the influence of structural features on the electroplastic effect, changes in the physical, mechanical, and technological properties of materials subjected to plastic deformation under current, possible mechanisms and methods of physical and computer modeling of the electroplastic effect, and potential and practical applications of the electroplastic effect are considered. The growing research interest in the manifestation of the electroplastic effect in such new modern materials as shape-memory alloys and ultrafine-grained and nanostructured alloys is shown. Various methods of modeling the mechanisms of electroplasticity, especially at the microlevel, are becoming the most realistic approach for the prediction of the deformation behavior and physical and mechanical properties of various materials. Original examples of the practical application of electropulse methods in the processes of drawing, microstamping, and others are given.

**Keywords:** pulsed current; deformation; electroplastic effect; deformation behavior; microstructure; properties; mechanisms of electroplasticity; modeling



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## 1. Introduction

The physical phenomena that occur when a pulsed current is applied to solid metal materials are well known. These include the thermal effect, the appearance of a magnetic field (and, as a result, skin and pinch effects), vibration, etc. [1]. Often, such phenomena occur simultaneously. The most notable among the listed effects is the thermal effect, which is often used in electric pulse treatment (EPT) technologies to change various properties due to the structural changes associated with the effect [2,3]. Note that EPT usually refers to technologies in which the object is not subjected to external deformation treatments. In the case of a combined effect on the material of simultaneously pulsed current and plastic deformation (for example, rolling, drawing, pressing, bending, tension, and compression), such processes are called electrically assisted manufacturing (EAM) or electroplastic deformation (EPD) in contrast to EPT. Those processes will be discussed in detail in this review.

The EPD is based on all the above mechanisms in interaction with plastic deformation (that is, with the movement of dislocations), which can be enhanced, leading to increased deformability and carried out at lower stresses due to the occurrence of the electroplastic effect (EPE) [4]. EPE is a phenomenon that depends on many external and internal factors [5]. The external factors include those associated with deformation. They are the scheme of the stressed strain state, strain rate, strain temperature, pulse-current modes, and regimes. Factors, such as the material, its structure, and phase composition, are internal factors.

# Deformation Processing

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