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THE INFLUENCE OF COLD ROLLING ON THE MICROSTRUCTURE FOR DRAWING STEELS

Florentina POTECAŞU, Octavian POTECAŞU, Elena DRUGESCU, Petrică ALEXANDRU, Miltiade ISTRATE, Doru HANGANU
"Dunarea de Jos" University of Galati
email: fpotec@ugal.ro

ABSTRACT

The paper presents the structural changes that appeared in steel for deep drawing, as a result of cold rolling and of recrystallization thermal treatment. The research was conducted on samples taken from the rolled strap, treated and rerolled after the present technology in Arcelor Mittal. For comparison samples sampled from the steel strap before cold deforming (hot rolled) were used as blank tests. The thermal processing was done under industrial conditions in bell furnace. For the chosen steel the critical deformation degree was around the value of 6.5%.

KEYWORDS: deep drawing steel, critical deformation degree, microstructure.

1. Introduction

The chemical composition of the analyzed steel is presented in table 1.

Table 1. *The chemical composition of the steel specimens used in experiments*

C	Mn	Si	S_{max}	P_{max}	Al
[%]					
0.04	0.25	0.1	0.009	0.012	0.05

In order to establish the influence of the cold deformation degree on the steel straps' properties, samples were sampled from a coil deformed on the continuous milling machine TANDEM with five four-high stands with the rolling cylinders' diameter of 550 mm.

To obtain samples with different degrees of deformation the rolling process was started and when the normal running regime was reached, the mill was stopped and cut off parts of the strap between the stands. To achieve deformation degrees lower than 20%, the rolling process was continued only with the first stand. Samples were taken for different deformation degrees: ε_1 = 2.2% ; ε_2 = 6.5% ; ε_3 = 15.2%; ε_4 = 32.5% ; ε_5 = 50.0% ; ε_6 = 65.0% (the deformation degree was calculated with the formula: $\varepsilon = \Delta h/h_o x100$).

The samples obtained after the cold rolling have been heat-treated under industrial conditions in bell furnace according to the diagram in fig. 1.

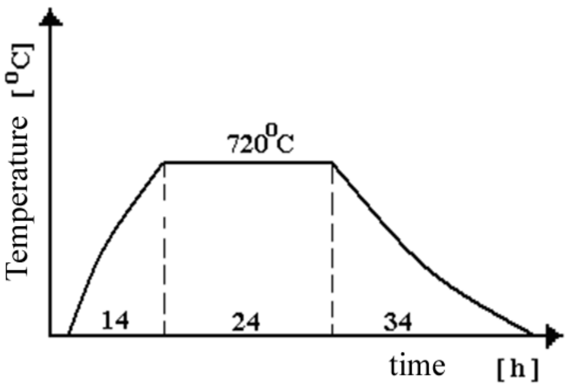
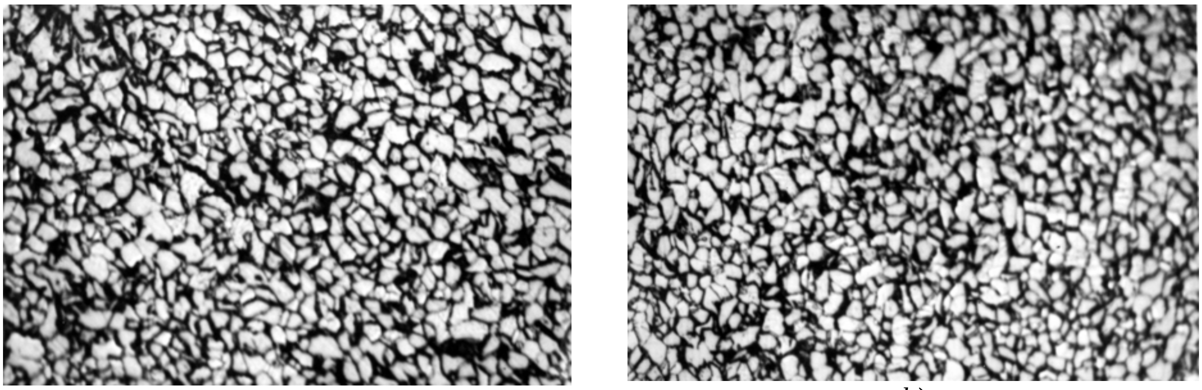


Fig. 1. *The diagram of thermal treatment conducted in industrial conditions, for the cold deformed samples with different deformation degrees*

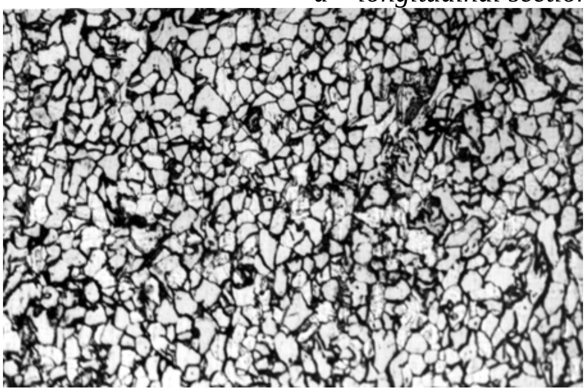
2. Experiments

The microstructure of the blank tests sampled from the hot rolled strap is presented in fig. 2 (a, b) and in fig. 3 are presented the microstructures corresponding to different deformation degrees, obtained through cold rolling (without thermal treatment). The microstructural analysis of the cold deformed samples, with different deformation degrees (ε_1 = 2.2% ; ε_2 = 6.5% ; ε_3 = 15.2%; ε_4 = 32.5% ; ε_5 = 50.0% ; ε_6 = 65.0%) reveal at high deformation degrees (over 50%) the occurrence of the fibrous structure, a highly noticeable aspect especially in longitudinal sections (fig. 3j and fig. 3l).

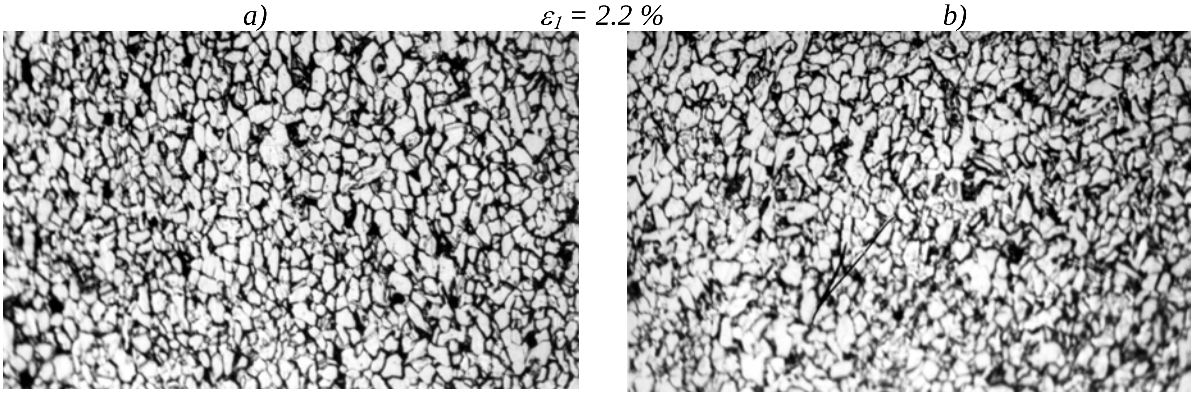


a) *b)*

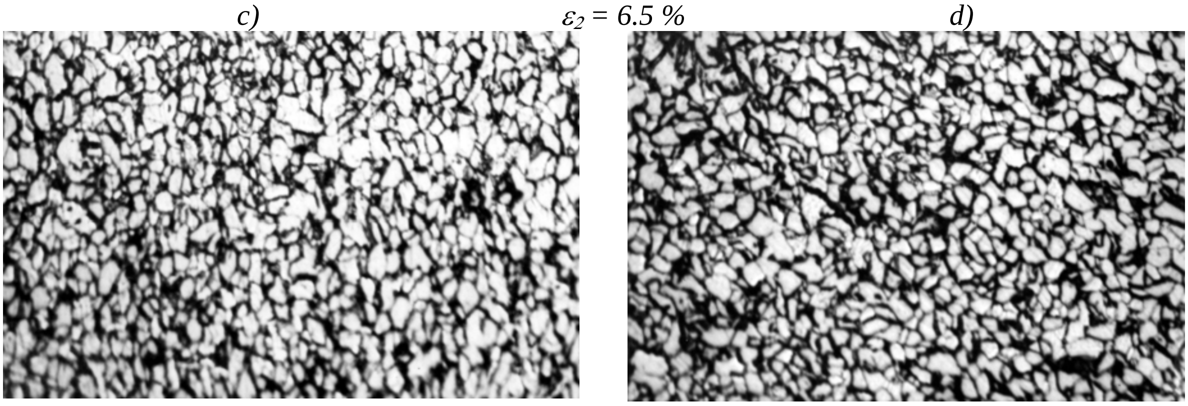
Fig. 2. *The microstructure of the blank tests (hot rolled):*
a – longitudinal section; b – cross section (x250).



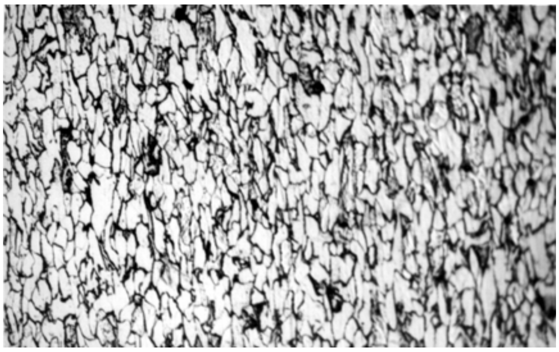
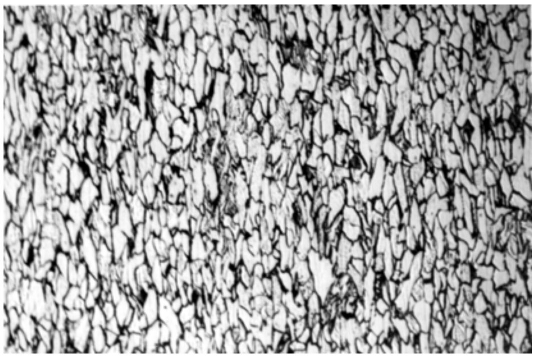
a) $\varepsilon_1 = 2.2$ % *b)*



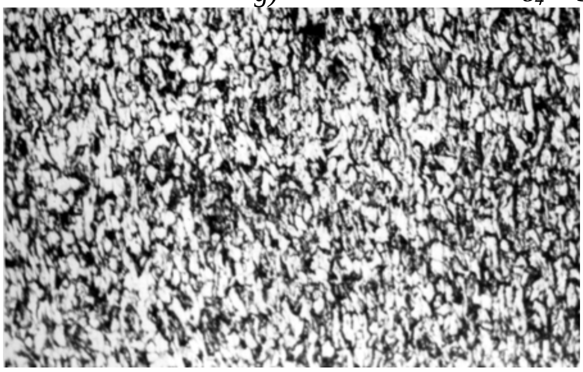
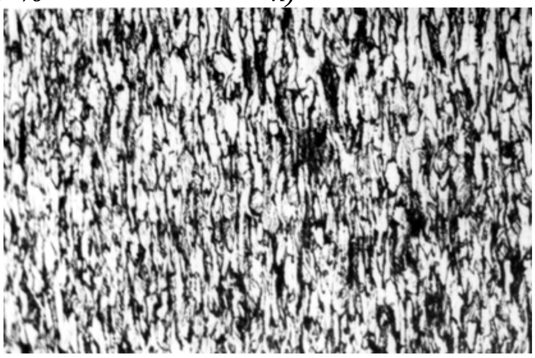
c) $\varepsilon_2 = 6.5$ % *d)*



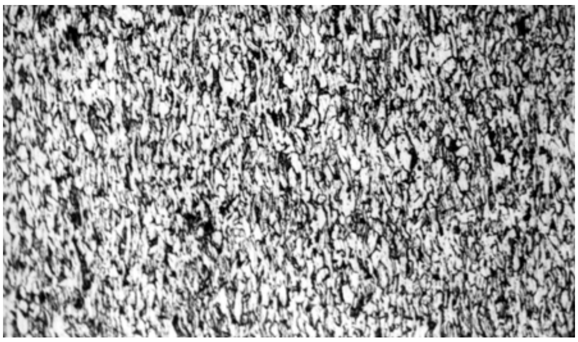
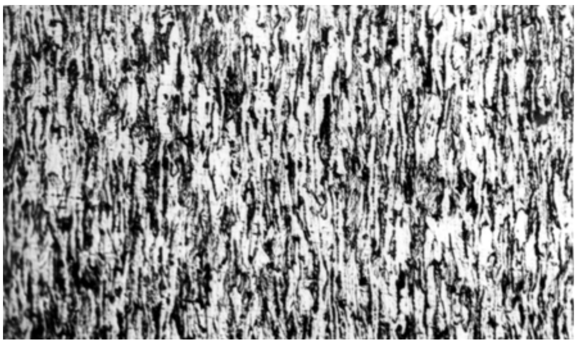
e) $\varepsilon_3 = 15.2$ % *f)*

g) $\varepsilon_4 = 32.5$ % *h)*

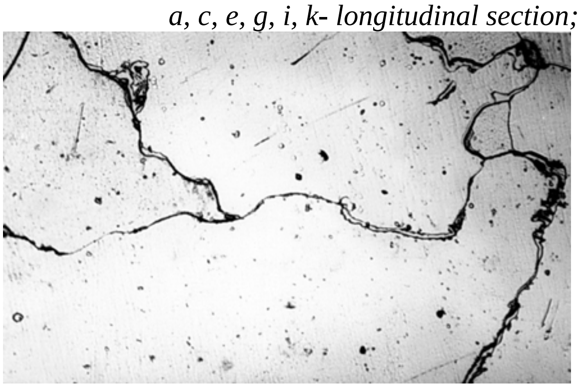
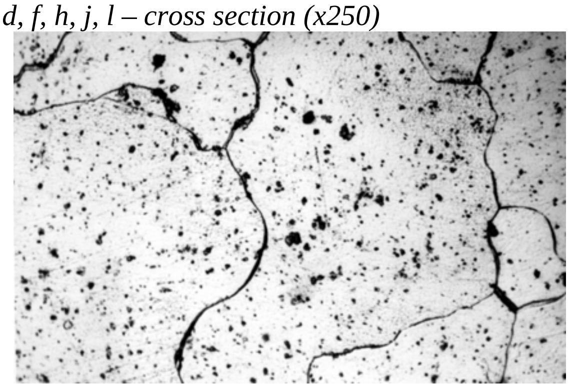



i) $\varepsilon_5 = 50$ % *j)*

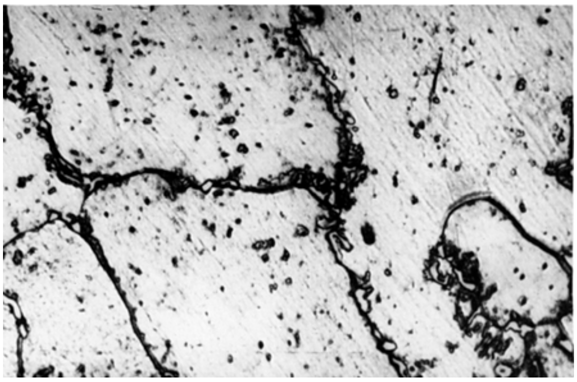



k) $\varepsilon_6 = 65$ % *l)*

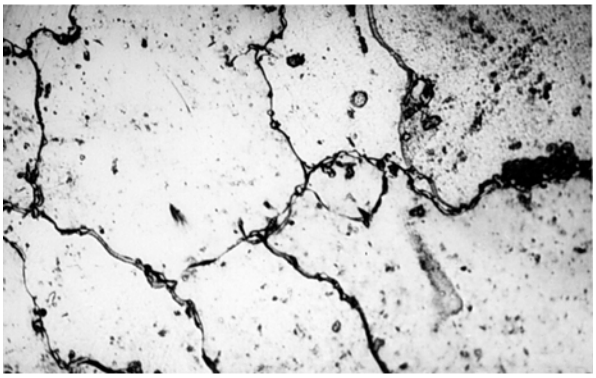
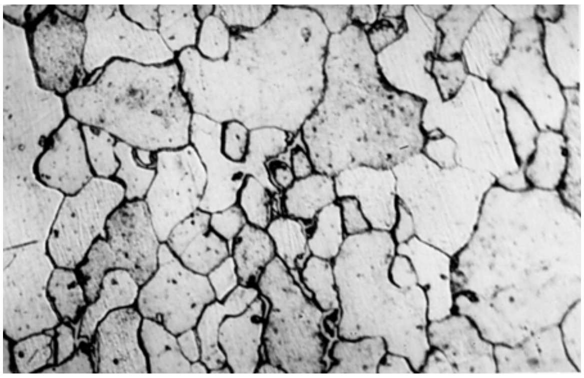
Fig. 3. *The microstructures of the cold rolled assays with different deformation degree made in: a, c, e, g, i, k- longitudinal section; b, d, f, h, j, l – cross section (x250)*

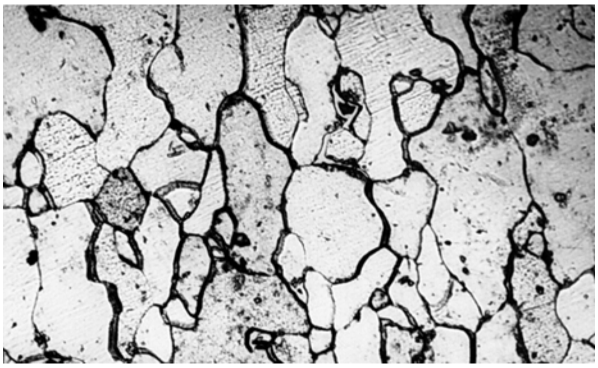
a) $\varepsilon_1 = 2.2$ % *b)*

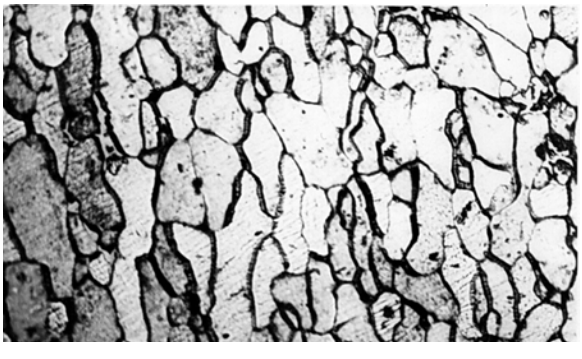
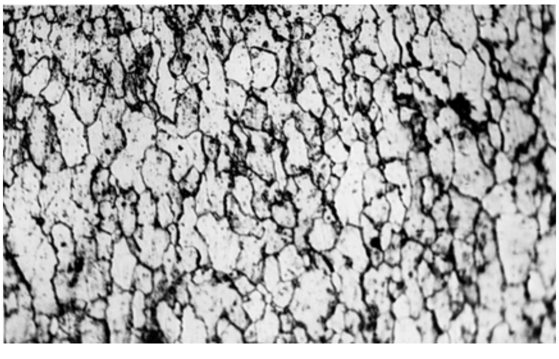
c) *ε_2 =6.5 %* *d)*

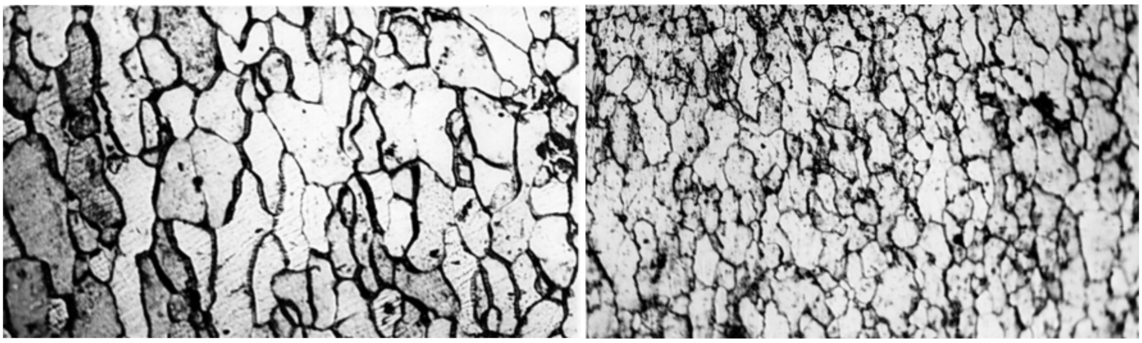
e) *ε_3 = 15.2 %* *f)*



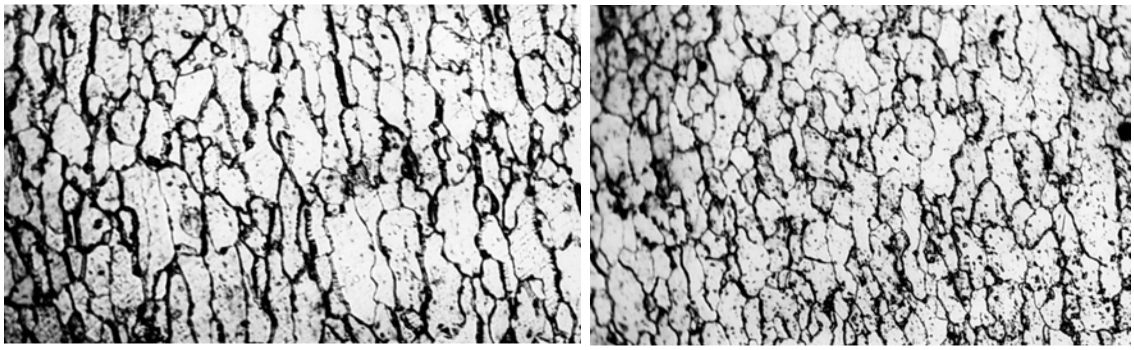

g) *ε_4 = 32.5 %* *h)*

i) *ε_5 = 50 %* *j)*



i) $\varepsilon_5 = 50$ % j)



k) $\varepsilon_6 = 65$ % l)

***Fig. 4.** The microstructures of the cold rolled samples with different deformation degrees thermal treated in industrial bell furnace made in: a, c, e, g, i, k- longitudinal section; b, d, f, h, j, l – cross section (x250)*

For the thermal treatment analyzed in this paper, one can notice that at small deformation degrees (6.5%) a coarse granulation is obtained (fig. 3), which leads to the conclusion that for the analyzed steel ***the critical degree of deformation*** is found around this value.

At high deformation degrees (over 32.5%), the granulation begins to finish itself and it gets finer as the deformation degree increases. This aspect of the microstructure appears both in longitudinal sections and in cross sections of the samples (fig. 5).

The analyzed microstructures showed that the samples analyzed under industrial conditions in bell furnace with long maintaining times, present an accentuated non-uniformity of the granulation in the strap's section, at small deformation degrees. When increasing the deformation degree (over 32.5%), this non-uniformity is getting higher.

In fig. 5 is presented the graph with the variation of the average diameter of the grains obtained after applying the thermal treatment for a long period of time, under industrial conditions in bell furnace, for the cold deformed sample sets with different deformation degrees (ε_1 = 2.2% ; ε_2 = 6.5% ; ε_3 = 15.2%; ε_4 = 32.5% ; ε_5 = 50.0% ; ε_6 = 65.0%).

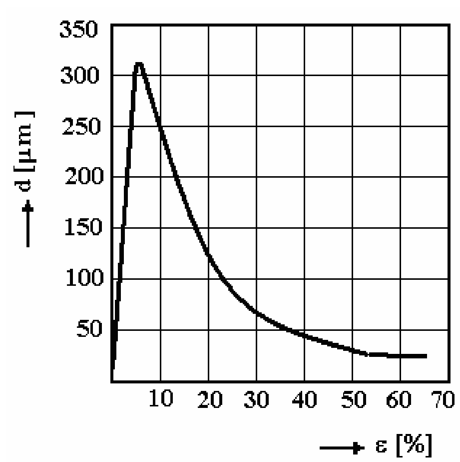


***Fig. 5.** The average dimension of the grains dependent on the cold deformation degree, for the heat treated assays under industrial conditions:*
T= 720^{o}C and maintaining time 24 hours

3. Conclusions

The granulation of analyzed steel is strongly influenced by the cold deformation degree.

The microstructures made for different deformation degrees show, for high deformation degrees (over 50%), a fibrous structure clearly seen on longitudinal sections.

The microstructures made from samples with different deformation degrees and industrial thermal treated show that the critical deformation degree for the analyzed steel is around 6.5%, the point were the granulation starts to grow in excess. Also for deformation degrees over 32.5% the non-uniformity of the longitudinal and transversal granulation diminishes.

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