Properties Analysis for Small Elements Added Shadow Mask Materials

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Abstract

Recently CRT is getting large-sized, Flatness and High Fine Pitched in the meantime the raw material for shadow mask is in rapid progress of thinness, Low Thermal Expansion and high strength.

Until now we have used AK(Aluminum Killed) & Invar(Fe-Ni alloy) materials for main raw material of shadow mask component. However recently Nb and Co addition and Nb+Co addition, which has advantage of Low Thermal Expansion and High Strength, has been developed as well as applying in mass production as CRT's trend has become more flat and fine pitch.

Among of them, Co addition has been mass production as forming type (Flat CRT) with the beneficial effect of low thermal expansion & high strength for the first time.

Since then Nb+Co addition has been used in mass production by the request of much higher strength of shadow mask component.

In case of Nb addition, It's thermal expansion coefficient is a little lower than normal Invar and a little higher than Co addition, meanwhile Its Mechanical property is almost similar to Co Addition.

The used samples of this experiment are 36%Ni + Fe, 32%Ni + 5%Co + Fe, 32%Ni + 5%Co + 0.3%Nb + Fe, 32%Ni + 0.3%Nb + Fe with heat treatment temperature of 600 ℃, 650 ℃, 700 ℃, 750 ℃, 800 ℃, 850 ℃, 900 ℃ respectively under the condition of 15min holding time.

After heat treatment, we have observed the change of mechanical property with addition of small elements through mechanical property investigation and metal structure observation as well as transition of thermal expansion coefficient by measuring of thermal expansion coefficient at 850 ℃.

In conclusion, 5%Co addition indicates that its thermal expansion coefficient is very similar under the condition of at 850 ℃ for 15min's heat treatment.

From the experimental result it is suggested that Co addition is mostly suitable for Doming property and Nb addition is mostly suitable for Drop property.

1. Introduction

Shadow Mask is a thin metal sheet with hundreds of thousands of small holes on it. It is placed behind a monitor screen inside the CRT. Shadow Mask, determining the distinction of images on the monitor screen, is one of the three key components of Color Braun tube. Until recently, Shadow Masks were made from AK(Aluminum-killed) steel possessing superior formability and etching ability and Invar steel possessing low thermal expansion coefficient faction of 10 times compared to AK. [1-2]

Recently CRT is getting large-sized, flatness and high fine pitched in the meantime the raw material for Shadow Mask is in rapid progress of thin, low thermal expansion and high strength.

There are two different types of Shadow Mask such as Tension and Formed Type applied to CRT Flatness. The main material applied to tension type is mostly AK(Aluminum-Killed) and formed type is mainly Fe-36%Ni Invar alloy. The tensile strength and creep property is very demanded in tension type while yield point and thermal expansion coefficient is critical factor in formed type.

Recently, the main trend of Invar alloy is shift to Nb, Co and Nb+Co alloy which are in the process of development and mass production. It's essential for tube maker to use low thermal expansion alloy to meet Doming property and high strength alloy to improve Shock property.

Therefore, We are going to find out most appropriate material through chemical composition, thermal expansion coefficient after annealing and mechanical property on heat treatment temperature in

comparison with recently developed alloy and conventional normal Invar alloy.

2. The result of Analysis

When it comes to chemical composition of specimen, A and B Specimens contain 32%Ni + 5%Co are almost same, on the other hand, C Specimen contain Ni32%+5%Co +0.24%Nb and D Specimen contain 36%Ni+0.28% Nb finally E Specimen are normal Invar(36%Ni)

With adding 5%Co composition, It will reduce thermal expansion coefficient and strength will be increased by adding Nb composition. With adding Nb composition, strength will be increased through solid solution hardening of Nb and precipitation hardening of NbC [3]

Also both low thermal expansion and high strength will be obtained by adding Nb and Co composition.

Fig. 1. The Chemical Composition of the TEST Sample

	Chemical Composition (wt%)							
	C	Si	Mn	P	Nb	Co	Ni	Fe
A	0.004	0.05	0.30	0.003	-	4.9	32.0	Bal.
B	0.005	0.01	0.26	0.001	-	4.9	31.9	Bal.
C	0.007	0.01	0.25	0.002	0.24	5.0	32.0	Bal.
D	0.005	0.01	0.03	0.002	0.28	-	36.0	Bal.
E	0.004	0.01	0.26	0.001	-	-	36.1	Bal.

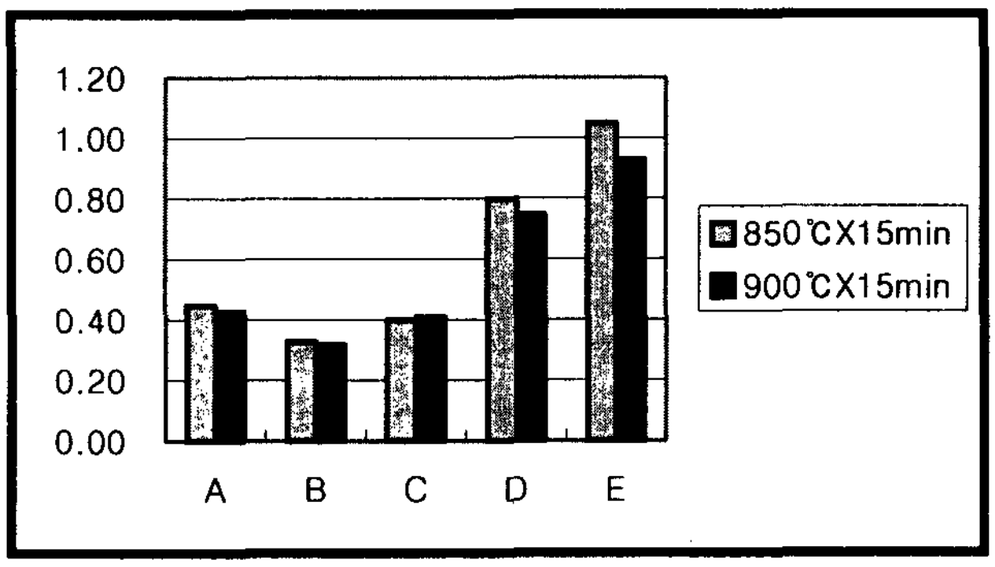
The Mn composition for D Specimen is reduced a faction of 10 times compared with other material as low thermal expansion coefficient is made by low impurity, on purpose.

The measurement result of thermal expansion coefficient is illustrated in Figur.2

The thermal expansion coefficient of A, B, C Specimen added 5%Co is about 0.4× 10-6/℃ and D Specimen added Nb is about 0.8× 10-6/℃ In case of C specimen added 5%Co+0.24%Nb, the thermal expansion coefficient is almost same as other specimens , indicating that it hardly affect thermal expansion coefficient even though it adds Nb Amount.

The low thermal expansion coefficient for Nb added alloy over normal Invar is contributed by a faction of 10 times of Mn amount rather than added Nb amount.

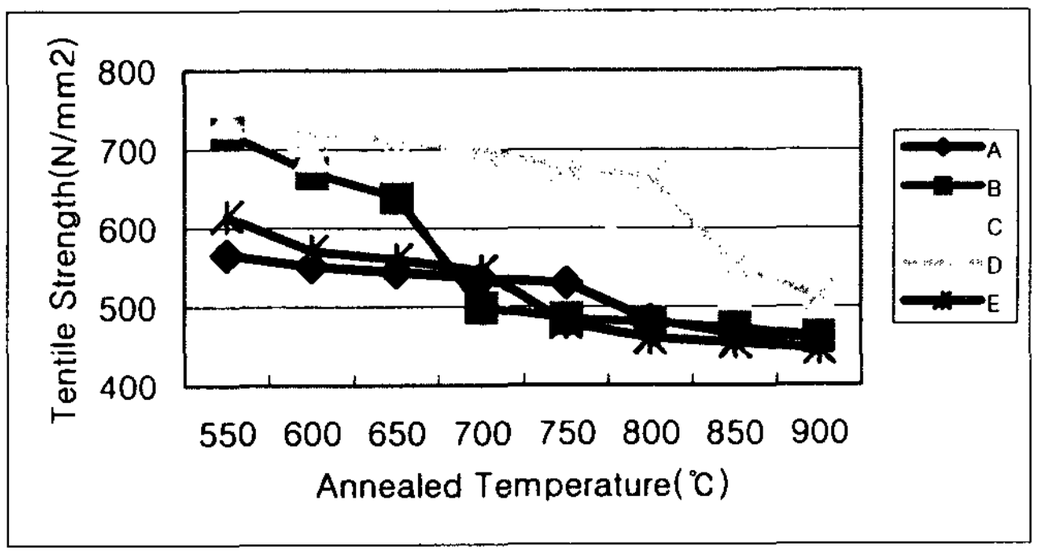
Fig. 2. The Results of Thermal Expansion Coefficient TEST.



The measuring method of thermal expansion coefficient at 850℃and 900℃ for 15min, respectively under the condition of 92%N2 + 8%H2 with increasing annealing temperature in the range of 30℃ to 100℃ in air, resulting in obtaining stretched amount, in other words, thermal expansion coefficient, with Laser .

The measurement result of mechanical property on heat treatment is illustrated in Figure.3

Fig. 3 The Results of Mechanical Property TEST



From analysis result of mechanical property , the Recrystallization temperature of each material is 750℃,680℃,800℃,850℃,750℃ , respectively .

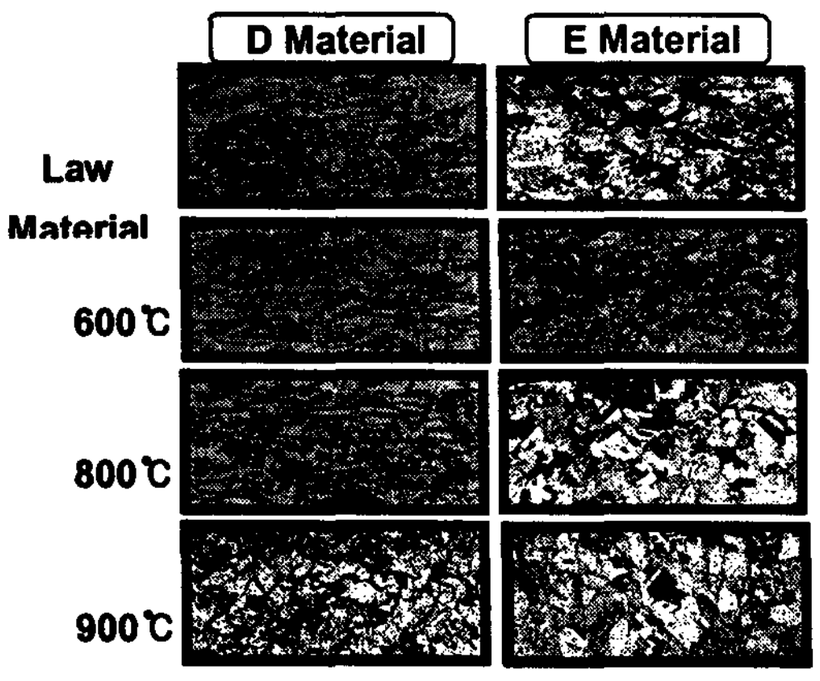
In terms of recrystallization temperature, it is presumed that B Specimen is most favorable and D Specimen is most unfavorable, in other words, Low recrystallization temperature take advantage of reducing annealing temperature in the first process. In addition, it indicates that recrystallization behavior is

totally different in terms of heat treatment process especially recrystallization temperature with the same chemical composition between A and B Specimen.

The highest strength material over the entire Temperature area is D specimen hardly occurring Recrystallization up to 800 ℃ which is very similar behavior as C specimen . In case of C, D specimen added Nb, strength property is superior over the entire heat treatment area. Also A, B specimen added Co has very higher strength in comparison with normal Invar alloy.

The metal observation structure on heat treatment temperature is illustrated in Fig. 4

Fig 4. The Results of Metal observation Structure



From above observation result, rolling structure of B, C, D material as raw material condition is different compared to A, E material and grain size of C, D materials added Nb is smaller compared to other materials such as A, B, E because of Nb composition by inhibiting grain size growth meanwhile increasing strength due to minute grain size fully recrystallized at 900℃

The grain size of A, B material added Co as raw material condition is very similar while grain size of A material is bigger than that of B under the same recrystallization condition.

However, It is suggested that smaller grain size does not mean higher strength even though tensile strength or yield point are same.

3. Conclusion

These results shows that Specimen A, B, C, whose thermal expansion coefficient around $0.4\times 10^{-6}/℃$, take advantage of Doming Property over normal Invar due to Superior thermal expansion coefficient and Drop effect owing to higher Strength after recrystallization.

Especially, added Co+Nb Alloy will be mainstream of "Super –Slim" Shadow Mask market in the future with superior thermal expansion coefficient and higher strength.

In addition, in the case of specimen D. , whose thermal expansion coefficient around $0.8\times 10^{-6}/℃$, is expecting to improve Drop Property of tube over normal Invar because of its low thermal expansion coefficient and higher strength after recrystallization.

4. References

[1] Hideo Saito "Physics and applications of Invar alloys", 1978 Maruzen Company, Ltd, Tokyo.

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[3] Masaomi Tsuda, Kun Wang, "The effect of alloying elements on the mechanical properties of the 36% Ni alloys", Iron and steel, Vol.82, No. 8, 1996.