process, the glass substrates themselves will suffer shrinkage or expansion to cause damage to the glass substrates. In the SPC process, as the crystallization temperature is higher than the glass transition point, a small temperature distribution can lead to significant deflection and shrinkage distribution in the glass substrates. As a result, even if crystallization is possible, troubles can take place in exposure step and other steps, making it difficult to prepare devices. A higher temperature uniformity is required with an increasing processing temperature. In general, the crystallization speed depends on the heating temperature, and a processing time of 10 to 15 hours at 600°C, 2 to 3 hours at 650°C, and several tens of minutes at 700°C are required, respectively. A long processing time is necessary to perform processing without causing damage to the glass substrates, making it difficult to use this method for mass production.

[0008]

The invention is achieved in such background circumstances with the aim of providing a crystalline film production method and production apparatus in which a fine crystalline film with a limited variation in crystal grains diameter is produced efficiently from the amorphous film without causing damage to the substrates.

[Means of solving the problems]

[0009]

Specifically, the crystalline film production method according to an aspect of the invention comprises irradiation of an amorphous film layer that is an amorphous silicon film formed on a substrate with a continuous-wave laser beam having a linear beam shape with a wavelength of 510 to 540 nm in the visible range without preheating of the substrate, the laser beam being relatively scanned in a direction of a short axis of the laser beam, to heat the amorphous film so that said amorphous film is heated up to a temperature not in excess of the melting point in order to crystallize said amorphous film.

[0010]

The crystalline film production apparatus according to another aspect of the invention comprises a laser

oscillator to emit a continuous-wave laser beam with a wavelength of 510 to 540 nm in the visible range, an optical system to shape a laser beam emitted from said laser oscillator into a linear beam shape and lead it to an amorphous silicon film and is not subjected to preheating, a scanning apparatus to cause a relative movement of said amorphous film to said laser beam in the direction of the amorphous film surface and in the direction of a short axis of the laser beam, and an attenuator to adjust the power density of said laser beam so that the amorphous film is heated and crystallized at a temperature not in excess of the melting point as the laser beam is being scanned by said scanning apparatus and irradiated / applied to said amorphous film.

[0011]

According to the invention, a continuous-wave laser beam in the visible range is applied to an amorphous film so that said laser beam is absorbed effectively by the amorphous film to heat the amorphous film rapidly up to a temperature not in excess of the melting point, making it possible to allow uniform fine crystals, such as those of 50 nm or less, with little grain size variation to be produced by a process that is different from the conventional melting and recrystallization process. When using the conventional melting and crystallization process and the SPC (Solid Phase Crystallization) process incorporating a preheating furnace, the resulting crystal grains will inevitably have a large variation in grain size. In the process of the invention, preheating is not necessary in addition to the heating of the amorphous film by applying the continuous-wave laser beam, and the amorphous film can be processed efficiently while controlling the heating of the substrate on which the amorphous film is formed.

According to the invention, furthermore, the same level of crystallinity is achieved also in those regions where the laser beam overlaps, leading to an improved uniformity. In the case of the conventional laser annealing process, crystals of a different structure are formed in those regions where the laser beam overlaps, leading to a decreased uniformity in crystallinity.

When processing an amorphous film, in particular amorphous silicon, the