Dynamics of zigzag destabilized solitary stripes in a dc-driven pattern-forming semiconductor gas-discharge system

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Zigzag destabilization of self-organized solitary stripes was detected recently in the current density of a planar semiconductor gas discharge system. In the present work it is revealed that this instability is accompanied by the propagation of the zigzag deformation along the body of a stripe. This phenomenon is quantitatively analyzed using a high-speed image acquisition technique based on a framing camera system. The velocity of propagation has been found to increase monotonously with the global electric current, while the characteristic wavelength of the pattern shows a complicated behavior. The connection of the obtained data to available results of theoretical analysis of secondary bifurcations of solitary stripes in reaction-diffusion media is considered.

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I. INTRODUCTION

Stripe patterns are well known structures being spontaneously formed in nonequilibrium systems of different origin [1–4]. Stripes can be observed experimentally as a part of a periodic pattern with a well defined wavelength [5–10]. A simple mode of destabilization of straight stripes is either a zigzag or a varicose bifurcation. These are related, respectively, to in-phase or out-of-phase wavy deformation of opposite walls of a stripe. The zigzag destabilization of periodic stripe patterns has been observed experimentally [11], and has been described theoretically as well [12]. Except in Ref. [13], to our knowledge no experimental results of zigzag destabilization of solitary stripes have been published so far. However, theoretically this kind of bifurcation has been treated by several authors, in particular for reaction-diffusion systems [14–18]. In theoretical works devoted to the problem, as a reference state solitary stripe solutions of two component reaction-diffusion equations have been chosen. As dependent on model assumptions, different kinds of zigzag destabilization of the boundaries of a stripe, including propagating and nonpropagating deformations, can occur. In contrast to the zigzag destabilization of solitary stripes, the zigzag instability of a periodic pattern of stripes is a collective effect, and cannot be observed for a single isolated stripe.

The destabilization of solitary stripes was recently detected experimentally [13]. In the present paper, experimental work presented in that reference is extended, and quantitative measurements of the properties of the zigzag destabilized solitary stripes are carried out. The experimental setup used is essentially the same as in Ref. [13]. It is a planar semiconductor gas discharge system that can be considered as a reaction-diffusion system [19]. In the present work the dynamics of the zigzag destabilization of stripes is evaluated experimentally by applying a high-speed optical camera. The experimental data are briefly discussed in connection with recent results of the theoretical analysis of this phenomenon in reaction-diffusion systems.

II. EXPERIMENTAL SETUP

The experimental system is shown in Fig. 1. Essentially, it is a planar gas discharge device with a semiconductor cathode being separated by a gas layer from an indium tin oxide (ITO) transparent metallic anode that is deposited on a glass substrate. The system is fed by the voltage U_0 in series with a resistor R_0 via the ITO layer and the metallic contact that covers the outer surface of the semiconductor. The semiconductor is a silicon (Si) wafer doped with the deep impurity of zinc (Zn). To obtain a low specific conductivity σ of the order of 10^{-11} $(\Omega\,\mathrm{cm})^{-1}$, the semiconductor is cooled down to a temperature of about 90 K by means of liquid nitrogen. To vary σ, the semiconductor can be illuminated by IR light with a radiation density φ_{IR}.

Since the metallic contact is transparent to IR light and due to the internal photoeffect in the semiconductor, σ can be increased proportionally to φ_{IR} in a large range. Therefore, σ (or practically φ_{IR}) can be used as a bifurcation parameter. Because the emitted radiation density in the visible range is roughly proportional to the current density j in the discharge gap [20], the spatial and temporal behavior of the current density can be recorded through the transparent ITO layer with optical cameras.

In the present experiments the semiconductor cathode has a thickness $a_1 \approx 1$ mm, the width of the discharge gap a_2 is in the range 0.75–0.8 mm, the active area has the diameter $d = 20$ mm. The gas that fills the gap is nitrogen (N_2) at pressure p in the range 160–220 hPa. The voltage U_0 ranges from 2.3 to 3.0 kV, and $R_0 = 1$ kΩ. Since the global current I_g in the device did not exceed approximately 100 μA in our experiments, the voltage drop on R_0 can be neglected with respect to U_0. The experimental parameters applied in the present work differ somewhat from those used in Ref. [13]; however, the qualitative behavior of the patterns is similar to that observed in that paper.

As mentioned above, the specific conductivity of the semiconductor and, therefore, the resulting current density can be interactively controlled by illuminating the semiconductor with IR light through the transparent electrical contact. In the experiments reported here, only a narrow rectangular area of size 1.8×20 mm^2 is illuminated (Fig. 1). The width of this area is of the order of the characteristic wavelength of the Turing-like instability that occurs on the two-

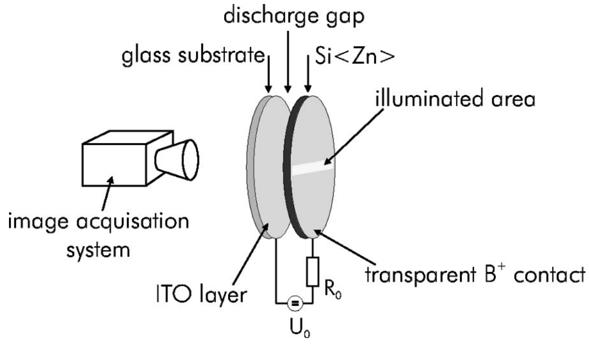

FIG. 1. Sketch of the experimental setup. The discharge is ignited in a discharge gap of 0.75–0.8-mm width which is filled with nitrogen at a pressure of 160–220 hPa. The supply voltage U_0 varies between 2.2 and 3.0 kV, while the discharge current, controlled with the illumination, varies typically between 10 and 110 μA. The spatial distribution of the current density is proportional to the emitted light, so that it can be recorded with a camera system through the transparent electrode.

dimensional domain of the device when a control parameter exceeds the critical value [20]. For that reason, only one stripe that may undergo bifurcations is selected.

For fast phenomena that are the main subject of the present research, a framing camera system (the model Hamamatsu C4187) has been used in most cases. This camera allows one to obtain series of at most eight frames in a picture with the maximum repetition rate of 3 MHz and a minimum exposure time of 50 ns for one frame. A built-in image intensifying multichannel plate allows to attain sufficiently bright pictures even at a short exposure time. In some experiments, where the high frame rate was not needed, a one frame intensified gated camera (DiCAM2 produced by the PCO company) was used.

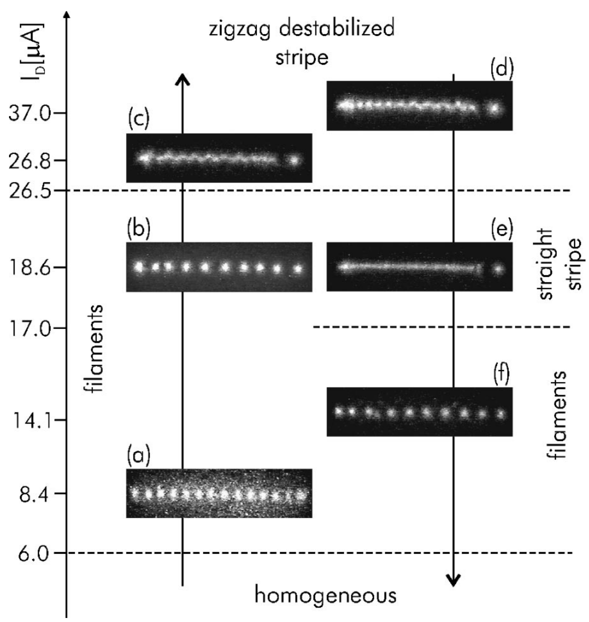

FIG. 2. Typical stages in the bifurcation scenario which lead to zigzag destabilized solitary stripes. The snapshots were made with the DiCAM2 intensified gated camera. The exposure time is chosen, depending on the brightness of the structures, to be between 0.3 and 0.9 ms. The current axis is not true to scale. The parameters of the discharge are the following: the pressure of N_2 is $p=160$ hPa, the supply voltage $U_0=2.3$ kV, and the discharge gap $a_2=0.8$ mm.

III. GENERAL FEATURES OF THE BIFURCATION SCENARIO

The former study of self-organized patterns in the above described device and in similar arrangements has shown that both low-amplitude spatially periodic structures do exist, such as hexagon and stripe patterns [20–22], as well as large-amplitude patterns in the form of single spots [23] and zigzag destabilized stripes [13]. In addition, zigzag destabilized spirals and targets have been observed [24].

In Ref. [13] it was demonstrated that at proper experimental conditions the device offers the possibility to initiate the growth of a stripe pattern through the variation of control parameters. Under these conditions the zigzag destabilization of stripes has been observed. The studying of this phenomenon on a two-dimensional active domain of the pattern forming device turned out to be a problem, because the state of parallel large-amplitude stripes has been noticed to be unstable. That is, stripes inside a pattern become curved, and the overall pattern can undertake the transition to a seemingly chaotic state.

To eliminate the above-mentioned complications, the device is fed with a certain voltage U_0 such that the entire circular active area exhibits a homogeneous stationary low current density (at the order of 5 μA/cm^2). However, in addition a narrow and long domain of the active area is illuminated homogeneously with IR light. Due to the low conductivity outside the illuminated area of 10^{-11} $(\Omega\ \mathrm{cm})^{-1}$ with respect to that of the illuminated part, the outer part can be considered as being insulating. In consequence, the illuminated domain can be considered as an effective active area with new rectangular boundaries. The width of this domain is chosen such that the development of only one single (solitary) stripe is possible. By increasing the illumination of the semiconductor electrode, a well defined stripe in the current density does self-organize. It is followed by a bifurcation to the zigzag destabilized state. In this way it has been possible to make observations of the behavior of a single solitary stripe in a wide range of control parameters.

The formation of a stripe, and its further destabilization into a zigzag, may go through complicated stages. In Fig. 2, some characteristic patterns in the system are presented that are observed under the variation of the control parameter inside the range of instability. Although in principle the intensity of the illumination of the semiconductor is the real experimental control parameter in our case the global current is used as the control parameter for convenience. This is justified, because the global current depends on the illumination in a continual and monotonic way.

One of the features of the shown scenario is that in the range of low global current the instability produces a spatially periodic pattern composed of current filaments. The spatial period of the pattern becomes larger when the current grows [compare Figs. 2(a) and 2(b)]. A stripe in the system exists at relatively high currents [see Figs. 2(c), 2(d), and 2(e)]. We point out that at large currents a partial fragmentation of a zigzag destabilized stripe is observed [Fig. 2(d)].

In general, the system is multistable, thus showing hysteretical behavior. One cross section of the multistable domain can be seen by comparing patterns in Figs. 2(b) and 2(e) that are obtained at the same global current but are different, as indicated in the figure. The two states shown have different prehistories. We suggest that the hysteretical behavior represented by the example just given is analogous to the existence of the multistability at transitions from hexagons to stripes on two-dimensional domains [25].

The hysteretic domain can be rather broad, e.g., for the scenario, snapshots of which are shown in Fig. 2. Here, on the ‘‘increasing’’ branch, there exists a stage of the transition from filaments directly to a zigzag destabilized stripe. For a two-dimensional domain, an analogous process exists: while sticking to each other, current filaments may construct such complicated quasilinear forms as zigzag destabilized spirals or targets [24]. For the ‘‘decreasing’’ branch in Fig. 2, a backward transition from a zigzag stripe to spots is not observed. Instead, a decrease in the current is accompanied by a transition from a zigzag destabilized to a straight stripe.

Starting from a solitary straight stripe, we have not observed hysteretic phenomena, while varying the current and observing bifurcations from a straight to a zigzag destabilized stripe and back to a straight stripe. Data analyzed in the present work have been obtained in this domain of the reversible formation and decay of the zigzag shape of a stripe.

We shall remark, however, that for large values of the feeding voltage the first bifurcation on a two-dimensional domain gives a stripe pattern [20]. For analogous experimental conditions on a restricted quasi-one-dimensional system, we have not observed a stage in scenarios that would contain a periodic array of current filaments and that would exhibit a notable hysteresis. Instead, a stripe can organize from a quasihomogeneous background and then undertake a zigzag destabilization. Both processes seem to be reversible.

IV. DETERMINATION OF SPATIAL WAVELENGTH AND VELOCITY

It was shown in Ref. [13] that zigzag patterns are essentially nonstationary. Attempts to make a quantitative investigation of their dynamics, performed in Ref. [13] failed, because the speed of the equipment used in those experiments was not fast enough. In the present work a high-speed image acquisition technique based on a framing camera has been applied. An example of raw data, a sequence of eight frames taken at a high repetition rate, is represented by Fig. 3(a). A detailed comparison of subsequent images of the pattern shows that in the course of time the deformation wave shifts along the body of the stripe.

In this paragraph, we describe the procedure used to extract information about the spatial wavelength of zigzag patterns and the velocity of their propagation along the stripe from the recorded experimental data. This procedure includes some special manipulations of the raw data, because a determination of velocity and wavelength from the local behavior of a pattern turned out to be a difficult problem. This is due to internal degrees of freedom in the zigzag pattern which lead to internal movements. These seemingly chaotic appearances prevent a straight determination of the parameters of the zigzag pattern. However, it turns out that despite these local nonregularities, the patterns as a whole possess a

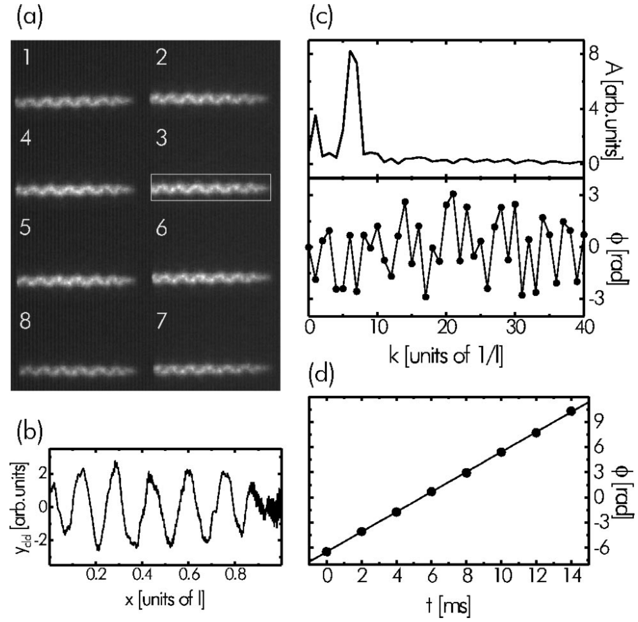

FIG. 3. Operations in data processing to determine the velocity and wavelength of a zigzag pattern. The raw data from the framing camera (a) consist of a succession of eight snapshots. The exposure time for each frame is 1 ms, and the repetition rate is 500 Hz. From the extracted region of interest, in the case shown from the third frame of the raw data where it is marked with a white box, the position of the center of mass of light density $y_{cld}(x)$ is calculated (b). The amplitude and phase spectrum of $y_{cld}(x)$ (c) are used to determine the phase of the strongest component as a function of time (d). In the case shown the strongest component is at $k=6$. The parameters are $U_0=2.8$ kV and $I_D=39.8$ μA.

quite regular collective behavior. In order to give a quantitative description of this behavior, the following procedure has been applied.

From each frame of a sequence a rectangular region of interest [marked with a white box in Fig. 3(a)] containing a stripe is extracted, and the background signal is subtracted before further analysis is done. The length l and height h of this region practically coincide with the dimensions of the active area of the device, which are determined by the illumination of the semiconductor. Because neither the position nor size of the illuminated area were changed during the experiment, the region of interest has been kept fixed for all frames.

Let the axis along the stripe be the x axis, and the axis perpendicular to the stripe be the y axis. Then the center of mass for the light density distribution in an image of a pattern along the y axis for each point on the x axis $y_{cld}(x)$ can be calculated [Fig. 3(b)]. This distribution $y_{cld}(x)$ provides a quantitative description of the zigzag pattern. Now it is possible to determine the wave number of this pattern by means of the Fourier analysis technique. The amplitude and phase spectra for the considered example are presented in Fig. 3(c). The amplitude spectrum shows a distinct peak at a small wave number, in this case the maximum of the peak is at $k_{max}=6/l$. The center of the power density differs slightly from the maximum value; in this case it is at $k=6.4/l$. Due to the rough discretization of the k axis, this is a more accurate value for the wave number of the pattern than k_{max}. The wavelength λ of the pattern is $\lambda = 1/k$; in the considered case $\lambda = 3.14$ mm.

The variation of the phase ϕ_{max} of the strongest wave number k_{max} with respect to time carries the information on the propagation of the zigzag deformation along the stripe. Values of the phase in subsequent time positions for the considered example are given in Fig. 3(d), which shows that the phase increases in time in a linear way. Therefore, the zigzag deformation of the stripe propagates in one direction for the whole time interval considered. We shall remark, however, that, to induce a unidirectional movement of a pattern, a slight gradient in the illumination along the x axis has been applied. In the case of spatial homogeneous illumination of the stripe-shaped active area, additional complications arise. The zigzag deformation of a stripe then tends to demonstrate changes in the direction of its propagation, with a frequency comparable to the frame rate of the camera needed to follow the dynamics of the pattern. This creates complications in the acquisition of quantitative data. Nevertheless, both cases—with and without a gradient in illumination—are discussed in Sec. V.

The general shape of the amplitude spectrum and the position of its maximum do not vary significantly in a sequence of pictures. Therefore, concerning its main characteristics, the zigzag pattern can be regarded as a rigid traveling object with the constant phase velocity $v_\phi = d\phi/dt$ of the strongest component in the amplitude spectrum. In the discussed example $v_\phi = 1.19$ rad/ms.

Eventually, the velocity v of the zigzag stripe results to be

$$v = \frac{1}{2\pi}\frac{v_\phi}{k}. \tag{4.1}$$

For the chosen example, the resulting velocity is $v = 0.60$ m/s.

To decrease the role of noise and above-mentioned irregular internal movements in a pattern in obtaining quantitative data, five independent measurements were done for each set of parameters U_0 and φ_{IR}. Then the raw data of the complete set of measurements were processed and averaged to obtain the final results.

V. EXPERIMENTAL RESULTS ON PATTERN DYNAMICS

Experiments in the present work suggest that, to follow the real speed of processes in patterns, the typical speed of recording devices should be some hundred frames per second. The main results of present experiments are summarized in Fig. 4, namely, the change of wavelength and velocity of the zigzag propagation along the stripe, in dependence of the discharge current for different values of the supply voltage U_0. The bars indicate typical errors due to problems in data processing mentioned in the preceding paragraph. All numerical values that are given in this work have an error of the same order. The plotted data represent the full range of zigzag destabilized stripes for each supply voltage. The size of this range depends on the supply voltage, and is the largest for $U_0 = 2.8$ kV. The behavior of the velocity shows common features for all supply voltages: the velocity increases with increasing current, at the same time being nearly independent of the feeding voltage.

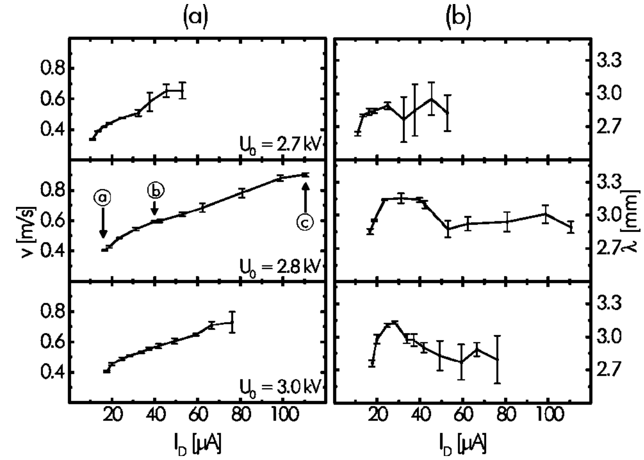

FIG. 4. Velocity (a) and wavelength (b) of the zigzag pattern for three different supply voltages $U_0 = 2.7$ kV, $U_0 = 2.8$ kV, and $U_0 = 3.0$ kV. The velocity increases with increasing current, while it is virtually independent of the voltage, whereas the wavelength shows a complicated behavior.

It is possible to distinguish two regions of current where both the velocity and wavelength show different behaviors. For higher currents the wavelength is nearly constant, while the velocity increases linearly with respect to the discharge current. At low currents, just after bifurcation from a straight stripe to a zigzag destabilized stripe, the velocity increases more quickly compared with the slope in the aforementioned linear range. Simultaneously, the dependence of the wavelength on the current is not monotonous. There is a maximum value for the wavelength. The nonmonotonic dependence of the pattern's wavelength on the control parameter may be related to the strong perturbation of the pattern by the physical boundaries of the active area of the device.

To illustrate what happens to the zigzag patterns while the discharge current is increased, some examples of stripes for different currents at $U_0 = 2.8$ kV are shown (Fig. 5). They correspond to experimental conditions marked on curves in Fig. 4. The first one refers to a small current just after the bifurcation, and the second lies in a medium current range. In both situations the zigzag pattern is fully developed, but in Fig. 5(b) it is brighter due to the larger current. The amplitude of the zigzag pattern itself shows no significant change when the current is raised. This seems to be related to the constriction of the active area in the transversal direction. At higher currents [Fig. 5(c)] the situation changes. A fragmentation process has begun, during which brighter and darker regions emerge in the pattern. Finally, this leads to a breaking up into single spots. This process is not investigated further in this paper. In the high current range, e.g., represented

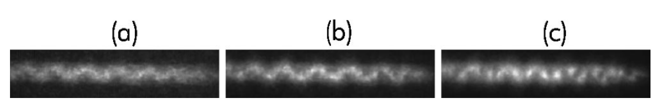

FIG. 5. Characteristic variations in the zigzag patterns at increases in current of (a) $I_D = 18.7$ μA, (b) $I_D = 39.8$ μA, and (c) $I_D = 110.6$ μA. The voltage is kept constant at $U_0 = 2.8$ kV. The conditions where these patterns are obtained are marked by corresponding letters in Fig. 4(a).

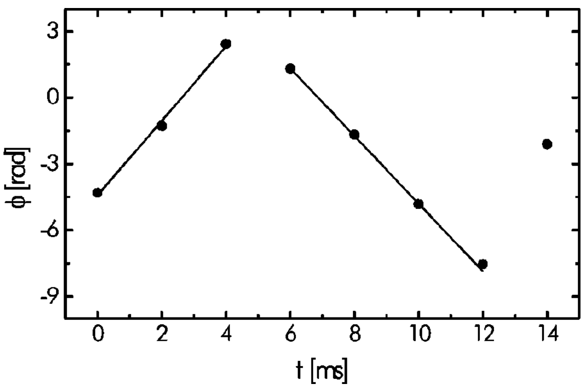

FIG. 6. Phase of the leading wave vector of the pattern for an eight snapshot series during which two changes in the direction of propagation take place. The parameters are $U_0=2.82$ kV and $I_D=38.3$ μA.

by the pattern in Fig. 5(c), the above mentioned internal chaotic movement occurs. Although a determination of velocity and wavelength for the high current range is still possible, the fluctuations are the cause of the larger error bars that are seen for higher current in Fig. 4.

In general, the direction of movement of a wave along a stripe is not prescribed, as already mentioned in Sec. IV. The results described so far were attained with a slight gradient in the illumination along the long extent of the rectangular active area, forcing the pattern to move in one direction. As demonstrated below, this gradient does not influence the absolute value of the velocity in an essential way. The breaking of the symmetry has been introduced because in the case of homogeneous illumination of the activated area of the device, it has been observed that in the course of one series with eight snapshots (which lasts, say, 15 ms) in most cases a zigzag pattern changes the direction of propagation. These jumps prevent the acquisition of proper data for a quantitative evaluation.

An example of the variation in phases of the leading wave vector of a pattern, for an eight snapshot series during which changes in the propagation direction take place, is shown in Fig. 6. Actually two changes of direction can be detected in this particular case. The first one takes place between $t=4$ and 6 ms, and the second one between $t=12$ and 14 ms. Obviously, only the situation before and after the first jump can be evaluated in the presented case. The absolute values of the phase velocity, as obtained from linear fits of the phase, are approximately equal: for $t<4$ ms it is 1.69 rad/ms, and for $t>$ 6 ms it is -1.53 rad/ms. The wavelengths are 3.40 and 3.36 mm, respectively. The resulting propagation velocities for the two directions are 0.9 and 0.82 m/s. The error in determining the phase velocity and wavelength in the considered case of a ''jumping'' stripe is larger than by making measurements on a regular moving pattern. For that reason, the velocities just mentioned are not in good coincidence with those that can be drawn from Fig. 4.

Jumps in the direction of the propagation of zigzag patterns along a stripe represent by themselves, a rather interesting example of patterns dynamics. The fact that these jumps have been frequently observed during the exposition time of one series indicates a rather high characteristic frequency of this jumping, in our case in the order of 100 Hz.

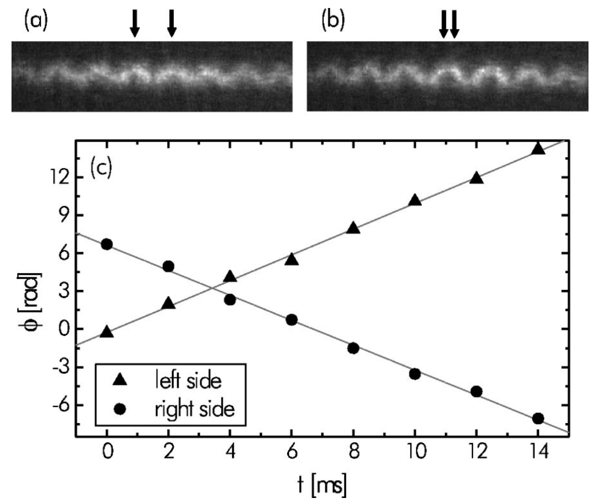

FIG. 7. An example of a stripe whose parts propagate in opposite directions. (a) and (b) are snapshots at two consecutive time positions, and (c) shows the variation of the phases of the main wavelengths of the left and right part of the pattern. The parameters are $U_0=2.6$ kV and $I_D=19.9$ μA.

In other experimental runs with a homogeneous illumination of the active area, two distinguished zigzag patterns, each extended approximately over half of the active area, are observed. These move in opposite directions toward the center of the active area, where they collide with each other. As a result, the point of collision oscillates in the vertical direction. Figure 7 shows two successive frames for this situation obtained with the framing camera. The maxima that are the closest to the center are marked here with an arrow for each side. The situation of oppositely moving zigzag patterns is retained at least during the acquisition time of one eight snapshot series. Figure 7(c) shows the phase—calculated from the strongest component in the Fourier spectrum of both constituents of the pattern in the same manner as for patterns of full length, as described above—as a function of time for both halves of the pattern. The resulting phase velocity is $v_{\phi,left}=1.02$ rad/ms for the left side and $v_{\phi,right}=-0.99$ rad/ms for the right side. The wave numbers are $k_{left}=7.15/l$ and $k_{right}=7.09/l$. Values of both the phase velocity and wave number for the two components of the pattern differ only slightly. Consequently, the absolute values of the velocity are nearly identical, in this case $v_{left}=0.45$ m/s and $v_{right}=0.44$ m/s. This agrees with the velocity measured in the situation described in Fig. 4 where the whole zigzag pattern moves in one direction. For example, for $U_0=3.0$ kV and $I_D=19.9$ μA, the velocity is $v=0.45$ m/s. These data suggest that the velocity of the zigzag pattern on a stripe is independent of the direction in which it propagates. The last result also shows that the slight gradient in the illumination of the semiconductor used in some experiments has no substantial influence on the velocity value.

The given examples concerning the observation of a switching of the direction of a zigzag mode in propagation, and the coexistence of domains of a stripe with opposite directions of propagation, show that the details of the dynamics of zigzag destabilized stripes are quite sensitive to the natural intrinsic noise of the experimental device. The system itself is homogeneous enough to support an equivalent propagation of the zigzag pattern in each direction. The switching itself must be triggered by small perturbations caused by noise. Under these conditions a slight artificial gradient in the system parameters, as used to obtain the data of Fig. 4, initiated a deterministic one-directional propagation of the zigzag wave along a stripe.

VI. DISCUSSION AND CONCLUSION

The phenomenon of zigzag destabilization of periodic stripe patterns (e.g., of convective rolls in the Rayleigh-Bénard effect) has been studied both experimentally and theoretically and has been well understood [11,26]. The progress in the experimental study of secondary bifurcations of localized objects in pattern-forming media has not been adequate so far, though considerable theoretical interest has been devoted to this problem [14–18].

The existence of zigzag destabilized solitary stripes in the semiconductor gas discharge system allows an experimental investigation of the dynamical properties of such an object. Due to the restrictions of the active area to a narrow rectangular zone, only one (solitary) stripe can be generated by the system. Under these conditions, a quantitative study of the dynamics of nonstationary patterns arising as a result of an instability of a primary stripe was possible. In essence, such a method of restricting the numbers of the degrees of freedom in the considered pattern forming system is conceptually close to that exploited in hydrodynamical systems [27].

In the present work, the zigzag destabilization of solitary stripes, that is accompanied by the propagation of a zigzag deformation of a stripe along its body, is studied. Such an effect was theoretically treated for reaction-diffusion systems in Refs. [14–18]. As a reference state for the analysis, a steady state stripe solution on a two-dimensional media has been considered. By varying control parameters, both varicose and zigzag instabilities for solitary stripes have been revealed. The detailed analysis of the problem made in Ref. [15] showed that, among a number of destabilizing modes, stationary and propagating zigzag deformations of a stripe can occur.

Numerical investigations of further processes that can develop in a reaction-diffusion system, due to the transversal instability of a solitary stripe, have shown that a zigzag pattern itself tends to granulate into smaller circular fragments [18]. A propagation of zigzag deformation along the stripe has not been found there. In the experiments discussed above the appearance of granulation of the zigzag destabilized stripe has been observed at relatively large currents far from the bifurcation from a straight to a zigzag destabilized stripe. Our results give evidence that the effect of stripe granulation can occur not only for a standing zigzag mode, but also for a propagating zigzag mode.

A natural question may arise concerning the connection between results of the theoretical research for reaction-diffusion systems done in Refs. [14–18] and experimental observations of the present work made on an electronic system. Contrary to chemical reactors, where normally an interaction of neutral particles takes place, transport processes in the considered device proceed due to the movement of charge carriers. The main components of the two layer system under investigation are a semiconductor with linear conductivity and a gas discharge domain that manifests a strongly nonlinear response of the electric potential across the discharge gap to the current density in the gap. An increase in current generally leads to the appearance of a negative differential conductance of the gap [28]. It is just this effect which is responsible for the emerging instabilities of the homogeneous current distribution in the system [19,23]. The transport of charge carriers is controlled mainly by regularities that are specified by the laws of dynamics of the electromagnetic field. However, a phenomenological consideration of processes that are responsible for arising spatial structures in two (linear and nonlinear) layer electrical systems has shown that one of the most important processes is the lateral coupling of the conductance processes in neighboring areas via the propagation of electric potential [29]. Despite the fact that this phenomenon is not directly related to the lateral spreading of a real matter, it is a diffusionlike process [19]. The change of the electric potential as a response to the variations in the electric current density, as well as the potential's propagation in the lateral direction, provide the inhibiting process and determine its spatial scale. The avalanche phenomena in charge carrier multiplication, which give rise to a negative electrical conductance of the gap, work as an autocatalytic process which also has its characteristic spatial and temporal scales. As a result of such an approach, two component reaction-diffusion schemes have been derived [19,23], that have been exploited successfully to interpret a number of pattern formation phenomena observed in semiconductor discharge systems.

To conclude, we have demonstrated the existence of propagating zigzag modes of solitary stripes in a pattern-forming system. While experiments have been done on an electronic (semiconductor gas discharge) device, the previous research showed that processes of destabilization of the homogeneous state, with a subsequent formation of spatial structures, are specific for reaction-diffusion systems. Therefore, we consider the regularities observed in the present experiments to belong to the dynamics of solitary stripes in reaction-diffusion systems.

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